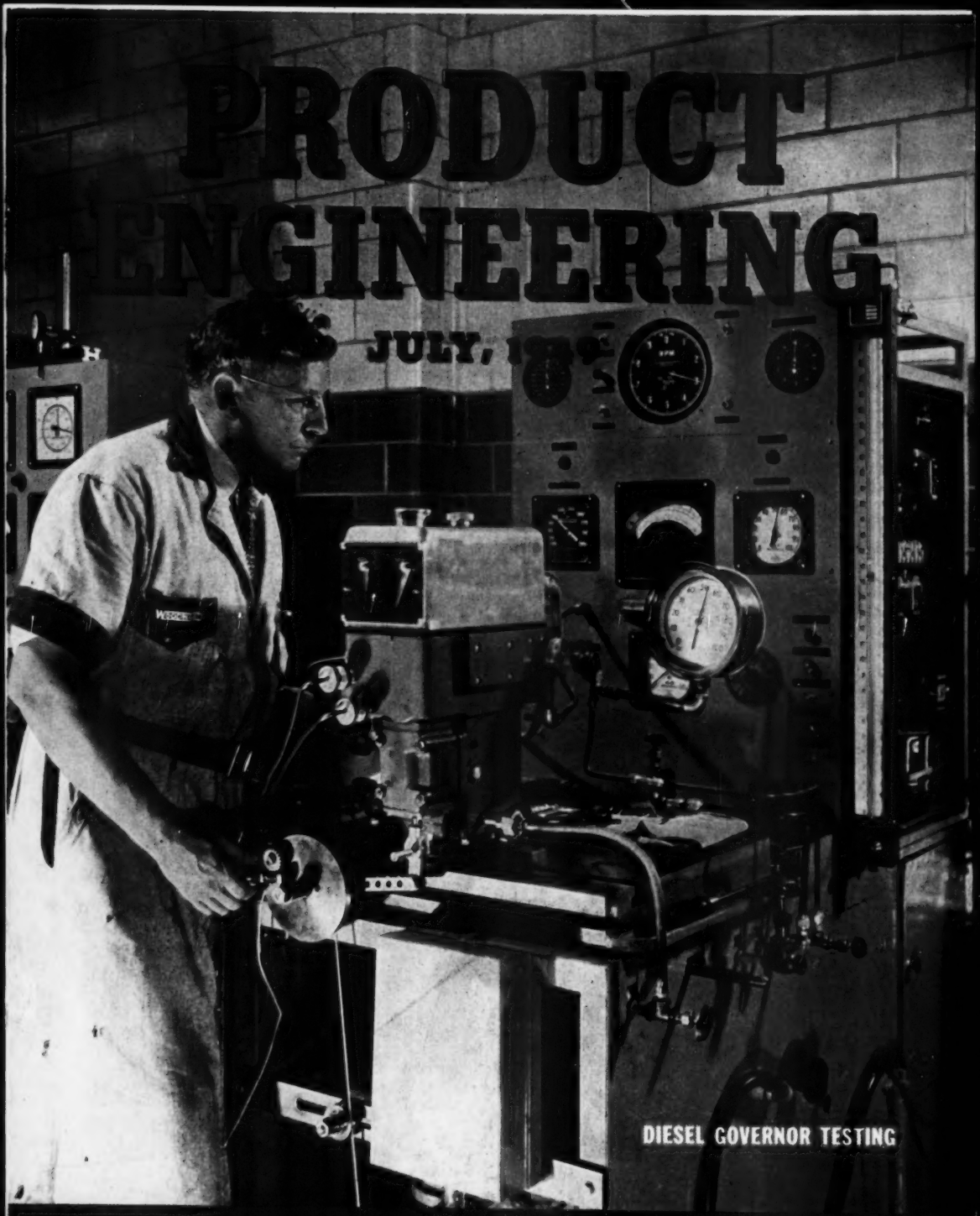
PRODUCT ENGINEERING



DIESEL GOVERNOR TESTING

STAINLESS lets you spin 'em BIG!

This large stainless steel tank end being spun to the desired radius is made up of standard width sheets of "18-8" welded together and the welds ground smooth.

(Below) Another large stainless steel tank end, already spun to shape, shown here being polished.

HERE is austenitic chromium-nickel stainless steel, Type 305, being spun into a huge tank end. Another, of Type 302 . . . spun to shape and receiving a polish . . . is pictured at the left.

These large units attest to the adaptability of austenitic stainless steels to this method of fabrication.

Types 302, 304, and especially Type 305, lend themselves well to modern spinning operations according to the producers of these tank ends, Milwaukee Metal Spinning Company (Spincraft) of Milwaukee 8, Wisc. On a production basis, this company spins heads and ends for milk storage tanks ranging from 36 to 102 inches in diameter.

This is only one of many applications in which advantage may be taken of the various useful properties of chromium-nickel stainless steels.

You can trim bulk and deadweight by specifying correct types of stainless. They are strong yet tough, moreover, they resist wear and abrasion.

You get long service life because these alloys are resistant to attack by nearly all oxidizing acid conditions. They assure long, trouble-free performance of equipment, and hygienic cleanliness as well as economy in food, drug, chemical and other process industries.

Leading steel companies produce austenitic chromium-nickel stainless steels in all commercial forms. A list of sources of supply will be furnished on request.

EMBLEM OF INCO SERVICE

Over the years, International Nickel has accumulated a fund of useful information on the properties, treatment, fabrication and performance of engineering alloy steels, stainless steels, cast irons, brasses, bronzes, nickel silver, cupro-nickel and other alloys containing nickel. Write for "List A" of available publications.

THE INTERNATIONAL NICKEL COMPANY, INC. 67 WALL STREET NEW YORK 5, N. Y.

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MALLORY PLATINUM-ALLOY CONTACTS

Serve in That Trouble-Free Thermostat on the Wall

Almost endless are the hidden tasks performed by different types of Mallory Contacts for products that make life easier and pleasanter. In the mechanism of the thermostatic heat control, for example, you'll find Mallory Platinum-Alloy Contacts doing their job with famous Mallory dependability and precision.

Mallory Platinum—alloyed for added strength, resistance to sticking, and hardness—makes a superb contact material where a high melting point, resistance to corrosion and oxidation, and retention of low contact resistance over long periods are required. Wherever a platinum alloy is needed, a Mallory Elkonium* contact material—produced under rigid controls—is available.

What's Your Problem?

You'll find Mallory Contacts in automotive voltage regulators—in electric business machines—in giant power plant circuit breakers—everywhere! Mallory has designed so many types of contacts that even if you have an unusual problem, chances are a standard Mallory contact will solve it. If not—Mallory engineers are prepared to develop the precise one for you. Consult them now.

For all kinds of contact materials and service, you can't beat Mallory as a dependable, experienced source.

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Electrical Contacts and Contact Assemblies

P. R. MALLORY & CO. Inc.

MALLORY

P. R. MALLORY & CO., Inc., INDIANAPOLIS 6, INDIANA

SERVING INDUSTRY WITH

Capacitors — Rectifiers
Contacts — Switches
Controls — Vibrators
Power Supplies
Resistance Welding Materials

*Reg. U. S. Pat. Off.

Highlights

In this summary of technical developments, space restrictions do not allow giving complete details. Further information relating to any item can be obtained by writing to the Editor of Product Engineering.

METALLIC MATERIALS

QUENCH CRACKING AND WARPING sometimes experienced when machining 75ST high-strength aluminum alloy can be avoided. Be sure that parts are symmetrical and structurally stiff; and, when dealing with forgings and billets, align principal grain directions with primary stresses.

A COATING OF LEAD-TIN ALLOY improves the flow characteristics of rosin flux solders on steel and brass parts, especially electrical components. Coating prevents oxidation; covers previously applied acid or electro-tin films, both of which are insoluble in rosin flux.

ALUMINUM DIE-CASTINGS make up more than half the parts of a 0.4 hp 2,000 rpm

single cylinder autocycle motor designed to meet the gallon-a-month gas ration in France. Nearly 300 miles per gallon is the selling point. Generator pole-pieces, and fuel pump diaphragm, as well as most of the stationary and moving power-section parts are light-weight castings.

BRIGHT NICKEL PLATE is being used more widely to cut plating costs without sacrificing quality or protection. Preliminary polishing and buffing are unnecessary and deposition is rapid--features especially useful when plating soft metals like lead.

ULTRASONICS are playing an important part in soldering aluminum. One application is joining fine aluminum and copper wires to produce a permanent electrical connection. Just twist uncleaned and unfluxed wires and immerse them in a pool of molten tin-zinc solder that is agitated at 10 kc per sec by a magneto-strictive tube.

HIGH-DENSITY SINTERED ALLOY of tungsten, copper and nickel powders is already being put to work in gyro-motors and self-winding watches, as well as a shield or filter for radioactive substances. Density is 16.9 grams per cubic centimeter; corrosion resistance good. Class 3 treads can be cut using carbide-tipped tools.

NONMETALLIC MATERIALS

NEW WAX PREPARATION makes an airplane windshield seem dry. Rain Repellent FC-10

breaks up the water into minute droplets that are quickly carried off in the wind stream. Treated surfaces permit visibilities up to two miles even at air speeds of 600 mph. While the wax does not shed ice, it does not prevent the de-icing action of standardized fluids.

CRAFT PAPER coated with a volatile organic crystalline compound acts as rust-proofing agent for metallic products. Just wrap the part like a parcel -- the chemical neutralizes corrosive action of moisture in adjacent air.

PHOTOSENSITIVE GLASS contains special optical sensitizers that permit printing of colored photographic images within glass articles. Lack of grain and resolving power make the glass ideal for scales and reticles in optical instruments of all types.

A MOLDED BUTYL SEALING COMPOUND is doing great things for current-reducing trans-

formers used in instruments, relays and meters. Compound is pressure injected around core, coils and terminals. No longer are laborious molding, varnished cambric wrapping and asphalt impregnating operations necessary.

"COLD-SETTING" PHENOLIC RESIN is both a protective coating and adhesive for wooden and normally-painted surfaces.

Continued on Page 5

In August, 1946, Gleasons announced localized tooth bearing in straight bevel gears and called this new development "Coniflex."*

ARE YOU EQUIPPED FOR TODAY'S REQUIREMENTS?

Today, Coniflex gears have proven superior to ordinary straight bevels. They are easier to assemble, operate smoother, and have wider operating tolerances. Coniflex gears, as cut on the No. 24A Straight Bevel Generator, are providing outstanding operation in power shovels and cranes, road machinery, ordnance and mining equipment, steel mill table drives and other heavy equipment.

For large gears, investigate the Gleason No. 24A Straight Bevel Generator . . . designed to cut the new Straight Bevels, Coniflex.

* Coniflex — Straight bevels with localized tooth bearing. Reg. U. S. Pat. Off.

The No. 27 Hypoid Tester, shown at left, (for testing the running qualities) and the No. 12 Generator Tool Sharpener, shown above, (to sharpen the cutting tools) complete the unit for complete production of Coniflex gears

GLEASON Works
1000 University Avenue
Rochester 3, N. Y., U. S. A.

Builders of Bevel Gear Machinery for Over Eighty Years

Glossy finish simulates baked enamel, is three times as hard as standard varnishes. Continuous temperatures of 300-350 F and most corrosive agents do not affect the plastic. As an adhesive, Phenoplast penetrates the fibers -- wood will split before the bond is broken.

READY-TO-USE PAINT in self-spraying containers is applied without brush or mixing by opening a valve at the top. A complete line of paints and finishes perfected for the purpose is used in pressure-packed containers that are of a size easily held in the hand.

POLYESTER LIQUID RESIN, called Permafil, acts as a reprieve for castings that might otherwise be scrapped because of excess porosity. Also permits use of castings subject to oil or vapor pressures. Castings are sealed by vacuum impregnation followed by a short oven bake. Finish is tough, clear and free of voids.

STYRENE-BASE MOLDING POWDER has high impact strength and excellent dimensional stability. Trade named, Plexene TA, thermoplastic is a competitor for opaque celulosics -- it's easily injection or compression molded, and extruded. Comes in full range of colors including white.

PROCESSES

FULL FATIGUE STRENGTH of magnesium alloys is retained by adding 7.5 percent sodium dichromate to a 3 percent selenium dioxide acid bath. Surface film adherence on Dowmetal M is an extra dividend of the treatment.

PERFECT ALIGNMENT of split-end connecting rods is quite simple. Rough machine and heat treat the forging with cap integral with the rod, break off the cap along a predefined plane, and reassemble for finish machining. This technique has been applied to aluminum bronze, as well as SAE 4615 and 3140 steel rods used in power lawn motors, outboard motors and other two-cycle engines.

A STEAM ATMOSPHERE does a better job of annealing non-ferrous parts than does air annealing and is less expensive than other controlled atmospheres. Preheated in air to 1,000 F, parts get the steam treatment which produces a thin protective adherent oxide. Process relieves stresses in brass parts and ages beryllium copper.

ELECTRO-CHEMICAL ANTI-TARNISH PROCESS protects silver, low karat golds, copper and its alloys from discoloration during storage. Known as Notarn, colorless coating is useful where lacquer is undesirable. It's already being considered for application to electrical contacts.

THE CONSUMER'S MARKET is steering many manufacturers toward alternate production methods that promise lower costs. This trend is especially true of non-ferrous parts that can be made either by sand-casting or hot forging. The latter method entails lower finishing costs prior to plating, less scrap during production, closer dimensional tolerances, increased tool life, and more attractive mechanical properties that lead to sounder parts with thinner sections.

NO DISCOLORATION, FLASH OR FILLET is produced on plated metal surfaces when stud welding by a new capacitance heating method. Since the current does not pass through the metal sheet, no fillet or "burned" spot is formed. Studs welded to die castings have a joint strength greater than the casting material itself.

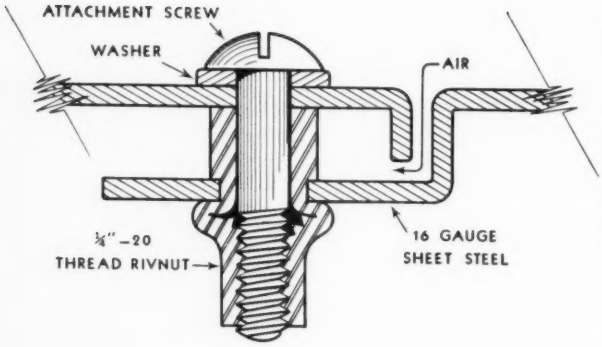
ELECTRICAL & MECHANICAL PARTS

SIXTY MESSAGES A MINUTE from a guided missile traveling at 1,500 mph -- that's what the Navy is doing with a radio-telemetering system. Electronic pick-ups strategically spotted in the missile feed signals to a transmitter that combines and sends them to a ground crew for recording.

FIRST REDESIGN of the French-type telephone since 1929 is getting close to the production stage. Instrument is 25 percent lighter, has an adjustment for bell loudness, contains a recessed dial with figures on the surrounding housing and features several "pot" type sealed circuit components that are quickly replaced when failure occurs.

Continued on Page 7

New ¼" RIVNUT solves tough fastening problem—replaces three parts



Designers of a new bus engine came up against a tough fastening problem in providing an air vent between two steel sheets of the engine housing. Because it was a semi-blind fastening job, the use of conventional bolts, nuts and spacers would slow production.

They found the answer in spacer-head Rivnuts. The ¼" steel Rivnut was inserted in the 16-gauge sheet steel and upset with power tool by *one* man, working from *one* side. The increased Rivnut head served as a spacer for the second steel sheet, which was firmly anchored by an attachment screw, threaded into the Rivnut.

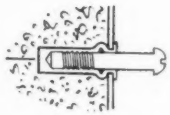
The ¼"-20 thread Rivnut provided extra strength, improved the design and cut costs. If you're faced with a fastening problem, why not call in a Rivnut engineer? Write the B. F. Goodrich Company, Dept. PE-79, Akron, O.

What's your toughest fastening problem?

TORQUE

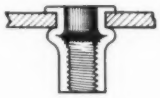
Special Rivnuts with splined shafts or key (above) supply needed torque resistance.

SEAL?



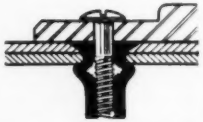
Firm grip of upset Rivnut on material, plus special closed end, gives tight seal.

MATERIAL?



Even in thin materials, Rivnuts provide a secure nut plate with at least six clean threads.

ATTACHMENT?



Rivnut serves both as blind rivet and nut plate, makes possible multiple fastening.

FINISH?

Rivnuts can be installed *after* finish, such as paint or porcelain, is applied.

LOADS?

Typical Rivnut thread strength: 6-32—784 lbs.; 8-32—1101 lbs.; 10-32—1220 lbs.*

RIVNUTS *lick them all!*

**Figures given for aluminum. Loads for brass and steel Rivnuts about double.*

B.F.Goodrich

RIVNUTS

The only one-piece blind rivet with threads

SEND NOW FOR FREE RIVNUT DEMONSTRATOR

Demonstrates with motion how you can use Rivnuts to fasten TO *and* fasten WITH. Explains construction, gives applications. Write to The B. F. Goodrich Company, Dept. PE-79, Akron, Ohio.

SPIRADYNE INDUCTION MOTOR will run at any speed within working range in either direction -- control is manual through a gear train. No commutators, brushes or auxiliary equipment are used. Stator flux is directed in a straight line parallel to rotor axis; stator phase poles are physically skewed until flux path becomes a spiral of variable steepness, either right or left. Speed-torque characteristics are similar to standard squirrel cage motor.

PILLOW-BLOCK has prelubricated sleeve bearing set in bushing or shell made of

neoprene. Dubbed Silent-Lign, device reduces noise and vibration transmission while compensating for both parallel and angular misalignment. Available in smaller shaft sizes from $\frac{1}{4}$ in. diameter.

SWIVEL CASTER has no king pin at all. Ball bearings ride between top plate and wheel fork stamping. Assembly is held together by a flanged retaining plate projection welded to center of top plate. Wheel diameters vary from 2 to 6 in.; load capacities from 90 to 500 pounds.

TESTING

COLORED MOTION PICTURES are fast becoming the stock-in-trade for specialized photo-elastic analyses. The colored film provides maximum discrimination of isoclinic and isochromatic stress patterns. Dynamic stresses can also be studied by this motion picture technique.

BABY ATOM SMASHER with a kick of 9,000,-

000 electron volts is now toddling around the Philips Research Labs in Holland Light in weight and easy to handle, the betatron can be taken to the job. The secret -- no heavy, expensive iron yoke is used.

LIQUID FLOW METERS using electric strain gage wire as the velocity measuring element may prove to be more accurate than pitot tubes, orifices and propellers. Placed in a tube at right angles to the axis of flow, the fine wire stretches parabolically in proportion to the fluid's velocity. Correlation with theoretical data is very close.

STRUCTURAL DESIGNERS worried about stresses developed in the swept-back

wings of supersonic planes may be able to sit back and relax. NACA researchers report that, at speeds above 1,500 mph, the straight wing is superior. But sections must still be extremely thin with a "sharp" leading edge.

A MICROSCOPE with quartz-fluorite lenses and a high-pressure mercury arc are the essentials for taking three-color pictures in black light -- the invisible ultra-violet range. Full color reproductions are made by passing green, red and blue light through the black-light negatives and combining the images.

PRODUCTS

MIDGET HEADPHONE about size of a nickel is claimed to be twelve times as sensitive as existing models. Fly-Fone earpiece weighs $\frac{1}{2}$ oz; detachable wire and belt-mounted jack add another 2 ounces.

COST REDUCTION in finished and semi-fin-

ished vinyl products is the result of a machine that does a complete compounding and extruding job. Several processing steps and expensive equipment such as Banbury mixers are therefore unnecessary.

A ONE-POUND GEIGER COUNTER is now a reality, the result of circuit miniaturization and redesign. Space required for the tube's power pack is reduced by using small components; interference from attached cables is minimized by cutting the power of the resistor coil to one-hundredth the standard value.

LARGEST ONE-SHOT PLASTIC MOLDING so far is Admiral's console television cabinet. A 2,000-ton press, used for making steel shell cases during the war, does the trick. Phenolic assembly weighs 35 lb; is 16 3/8 in. wide, 32 1/8 in. high and 17$\frac{1}{4}$ in. deep. Turn to page 105 for details.

ELECTRONIC SLIDE RULE for solving complex equations aligns data voltages according to time instead of in distances as on the standard slip stick. Such time scales can be logarithmic, linear, trigonometric or combinations of these basic functions.

How the base metal protects the finish

Progressive steps in the production of this emblem in red, white, blue, black and gold vitreous enamel and heavy gold plate, as made by American Emblem Company, Utica, N. Y.

(1) The metal is blanked from sheet stock. (2) First coining operation. (3) Second coining operation. (4) The excess metal is trimmed. (5) Attaching devices are welded. (6) First vitreous enamel charge has been fused by firing. (7) Second vitreous enamel charge has been fused by firing. (8) The enamel colors are stoned smooth. (9) Enamel has been given a final fusing and buffing. (10) The plate is electro gold plated.

(1A) The metal is blanked from sheet stock. (2A) The design is coined. (3A) The excess metal is trimmed and holes pierced. (4A) Attaching studs are welded. (5A) The plate is buffed and chrome plated. (11) The two pieces are assembled. (12) Finished plate as passed by inspectors.

This is a typical example of a fine emblem, combining good design, excellent materials, and a high degree of art and craftsmanship in production.

It is almost always the case, though unsuspected by the general public, that the material to which a finish is applied has a definite influence upon the perfection and durability of that finish. For example, products that are nickel or chromium plated stand up better if the base metal is non-rusting, as is copper and brass. To take another example, look at vitreous-enameled emblems, used as trademarks, name plates, medals, lapel pins, insignia, and so on. Most of these emblems have a copper alloy as the base metal; only that, or gold or silver, can be used.

These emblems owe their beautiful and permanent colors to silicate pastes and powders, inlaid by skilled artisans, and twice fused in a furnace at a temperature of about 1500° F. This temperature sets high standards for the underlying metal which must not warp, nor "bubble up" into the enamel. Thus visible beauty for which so much creative skill is required, depends in part on the invisible metal underneath. Revere, which takes great pains to maintain the strict standards of its alloys, is proud to meet the high requirements of American Emblem and other companies in this field . . . Perhaps Revere can help you by supplying exactly what you require to protect the finish and durability of your product.

REVERE

COPPER AND BRASS INCORPORATED

Founded by Paul Revere in 1801

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• • •

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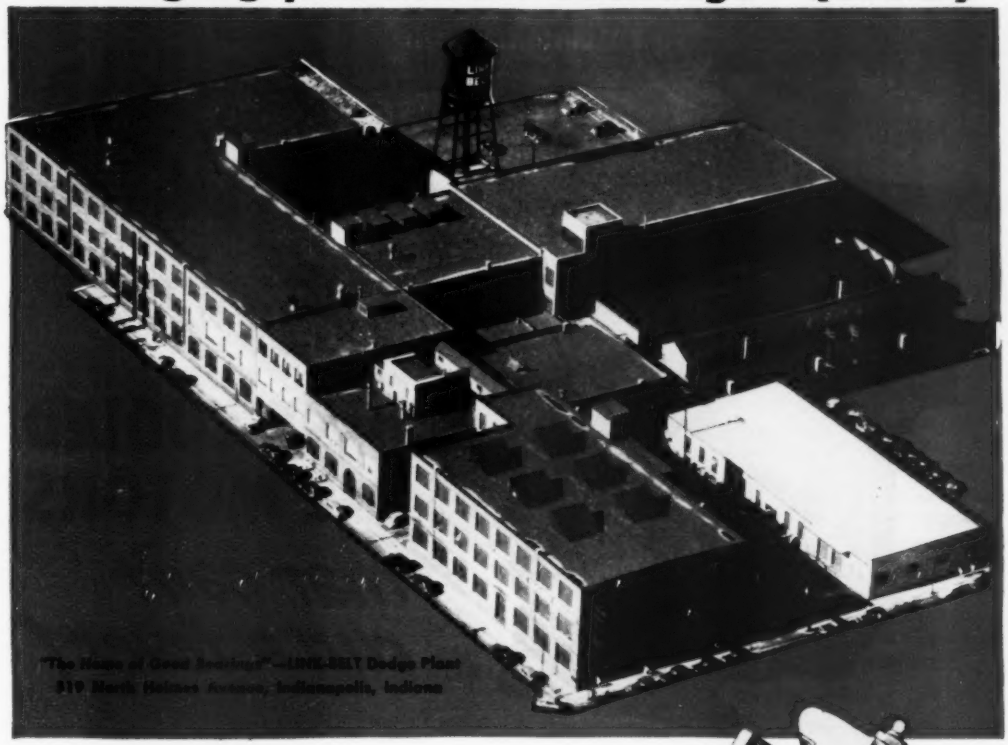
Sales Offices in Principal Cities, Distributors Everywhere.

One LINK-BELT Plant devoted *Solely* to bringing you better bearings—*Quickly*



"The Home of Good Bearings"—LINK-BELT Dodge Plant
519 North Holmes Avenue, Indianapolis, Indiana

Meeting industry's ever-increasing demands for ball and roller bearings that offer the desired combination of free-rolling action, self-alignment, and long life is no small-sized job.

That's why the entire capacity of Link-Belt's Dodge Plant in Indianapolis is devoted to this important task.

From the receipt of housing castings furnished by sister plant foundries to shipment of finished mounted bearings, alert design engineers, skilled craftsmen and the most modern bearing production machinery work hand-in-hand to turn out the bearings that enable users to TURN SHAFTS EFFICIENTLY.

Cut-away view of Series 200 Ball Bearing Pillow Block

LINK-BELT COMPANY

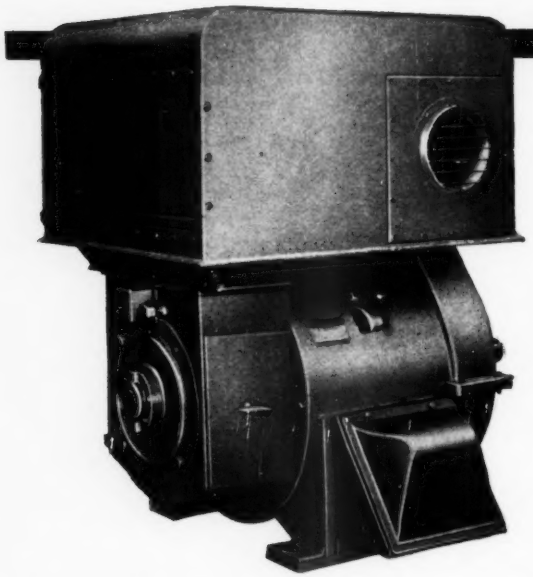
Indianapolis 6, Chicago 9, Philadelphia 40, Atlanta, Dallas 1, Minneapolis 5, San Francisco 24, Los Angeles 33, Seattle 4, Toronto 8. Distributors in Principal Cities

11,387

LINK-BELT

Ball and Roller BEARINGS

Designer's



New!

UNIT-COOLED D-C MOTORS

that can't run a fever!

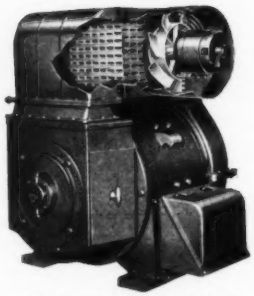
For applications where dirt, dust, or oil-laden atmospheres make it difficult to use open or partially enclosed motors, here's the newest improvement in General Electric standard, totally enclosed, unit-cooled d-c motors—ventilation entirely independent of motor speed.

In adjustable-voltage systems, these Type CD motors can be run well below full-field speeds over long periods of time and deliver full torque continuously, without danger of overheating. Full ventilation at all times is provided by a single Tri-Clad* induction motor driving two blowers at constant speed – one circulating internal air, the other external air.

Still available, to meet your limited speed range requirements, is the single-blower type. In this less expensive motor the internal cooling air is circulated by a shaft-driven fan.

With either type, no piping, ductwork, air filters or pressurized air supply are needed. Both are available in ratings from 15 to 200 hp. See Bulletin GEA-4469 for details of single-blower type; new bulletin on two-blower type will be available in a short time.

*Reg. U. S. Pat. Off.



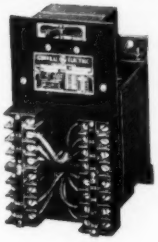
In this cutaway illustration of the G-E single-blower unit-cooled d-c motor, note how motor air, never in contact with contaminated outside air, is cooled by flowing through passages set at right angles to the external air passages. Safe winding temperatures are maintained at all times.

GENERAL ELECTRIC

Digest

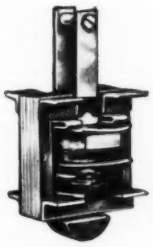
PRODUCT HIGHLIGHTS

MEETS MORE NEEDS—
WITH ADDED RATINGS!



Yes, General Electric's standard line of machine-tool control transformers can now be applied to a greater variety of your designs. Five new additions have been made to the all-purpose (multi-tap primary) group, widening the available range to include ratings from 0.150 kva to 3.0 kva. These compact, versatile units save panel space, reduce inventory and storage costs, and contain built-in protection against damage from sustained overload. Many ratings are in stock, at attractive new prices.

PROVIDES PUSH OR PULL—
ELECTRICALLY!



Need a reliable straight-line push or pull motion in your machine? It's a precision job with G-E heavy-duty solenoids, made in a complete line for a-c or d-c. Available maximum stroke distances range from ¾-inch up to 3 inches, and thrusts from 0.65 pounds up to 97 pounds. New bulletin gives complete information on ratings, plus a section on considerations in selecting a solenoid. See Bulletin GEA-5163.

GAGES ROUGHNESS—
BY "RULE OF THUMB"!

Here's a handy, simple way to test machined surfaces by feel and sight. With General Electric pocket-size roughness scales, shop men can quickly check whether finished surfaces meet your specifications. Result: time spent on unnecessarily fine finishing and rejects due to insufficient finishing are both avoided. Set includes leather case and two 6-inch metal scales divided into 24 surfaces. Available immediately. See Bulletin GEC-311.

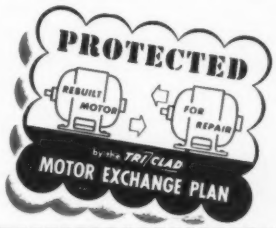
Now—bringing you more customer goodwill

THE *TRI CLAD* MOTOR EXCHANGE PLAN

You can now give your customers added assurance of operating continuity in the machines you equip with Tri-Clad motors—already the best-protected general-purpose motors money can buy. General Electric's new Tri-Clad Motor Exchange Plan relieves you of motor service responsibility, eliminates the need for you to maintain motor repair facilities. Your customer profits by extra down-time protection, lower-cost motor maintenance, and reduced spare-motor inventories.

How the plan works

If your customer's motor needs repair, his dealer or distributor exchanges it for a factory re-conditioned motor carrying a new-motor warranty—quickly, with no red tape. Inoperative motors are quickly replaced from the nearest of 16 General Electric motor-exchange centers. For full information on the plan see Bulletin GEA-5180.



General Electric Company, Section G668-74
Apparatus Department, Schenectady 5, N. Y.

Please send me the following bulletins:

( ) GEA-4469 — Unit-cooled d-c motor
( ) GEA-5163 — Heavy-duty solenoids
( ) GEA-5180 — Motor exchange plan
( ) GEC-311 — Roughness scales

CONSULT YOUR McGRAW-HILL ELECTRICAL CATALOG FOR PRODUCT ENGINEERS! You'll find "everything electric" for machinery manufacturers in the General Electric section.

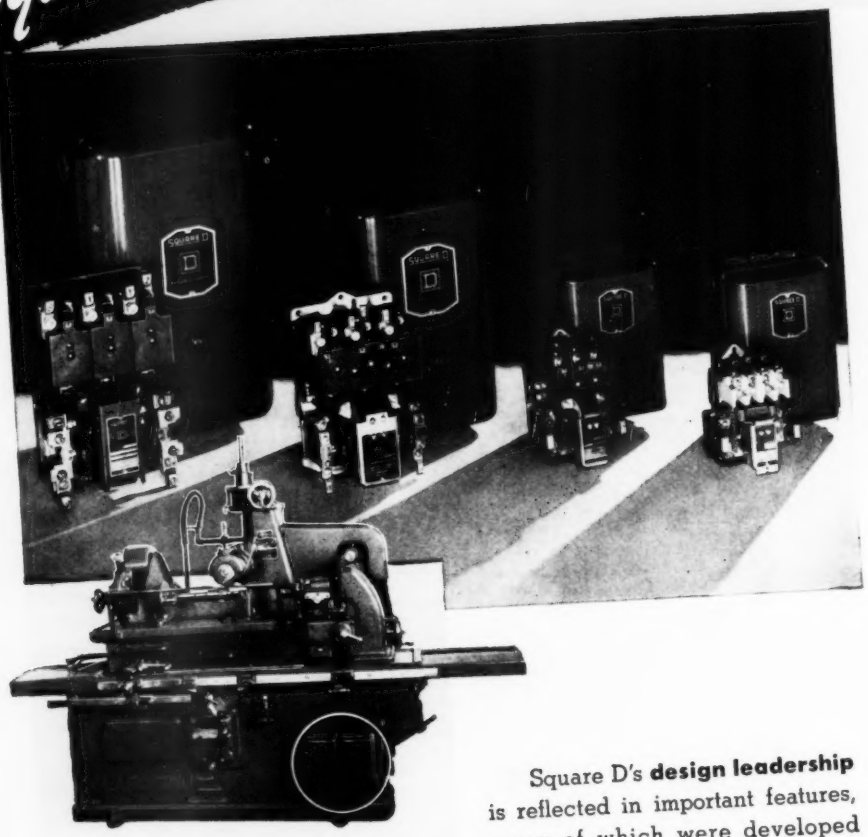
Name.....

Company.....

Street.....

City.....State.....

Square D MOTOR STARTERS



Square D's **design leadership** is reflected in important features, many of which were developed specifically to meet the requirements of the machine tool industry.

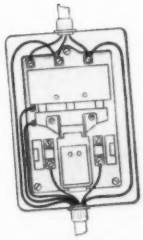
Generous wiring space . . . simple contact change . . . quick coil removal . . . additional electrical interlocks . . . long life . . . NEMA standardization . . . simplified maintenance. These are features which put Square D on the preferred list of many of the country's outstanding machine tool builders.

SQUARE D COMPANY

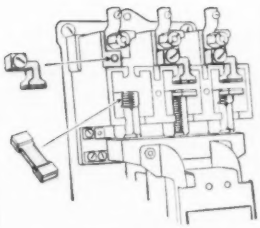
DETROIT • MILWAUKEE • LOS ANGELES

SQUARE D COMPANY CANADA LTD., TORONTO • SQUARE D de MEXICO, S.A., MEXICO CITY, D.F.

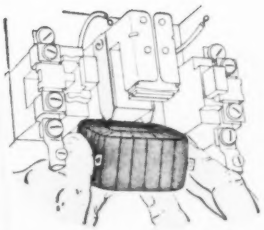
—an example of DESIGN LEADERSHIP



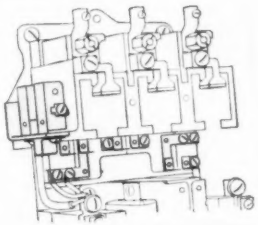
1) EASY TO WIRE—Compact starter design provides generous wiring space with minimum box size. Either pressure wire connectors or solderless lugs permit leads to be attached quickly and securely.



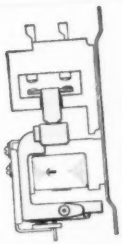
2) SIMPLE CONTACT CHANGE—Removal of arc chamber cover exposes all contact surfaces. Two-piece stationary contact allows replacement without disturbing wiring.



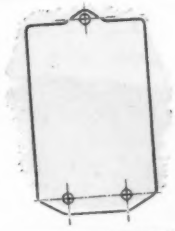
3) QUICK COIL REMOVAL—Coil readily accessible by removing arc chamber cover and lifting off armature assembly. Screwdriver only tool required.



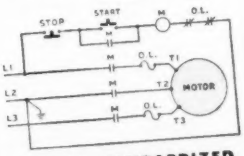
4) ADDITIONAL ELECTRICAL INTERLOCKS—Wide variety of available combinations adds flexibility to starter use in special applications.



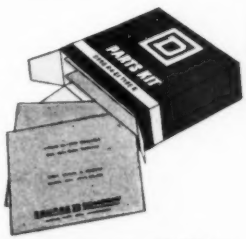
5) LONG LIFE—Straight line, guided motion of armature and movable contact assembly eliminates bearing, simplifies construction, reduces wear.



6) NEMA STANDARDIZED MOUNTING—Base plates of Size 0, 1 and 2 starters have NEMA standard mounting holes but are also interchangeable with previous designs.



7) NEMA STANDARDIZED WIRING provides added safety, permits standardized diagrams and simplifies interchangeability of equipment.



8) PACKAGED PARTS—clearly identified, simplify normal maintenance and minimize replacement part ordering and stocking problems.

Write **for BULLETIN #8536**

SQUARE D COMPANY
4041 N. Richards Street
Milwaukee 12
Wisconsin

graphitar
(CARBON-GRAPHITE)

problem in rotary pressure

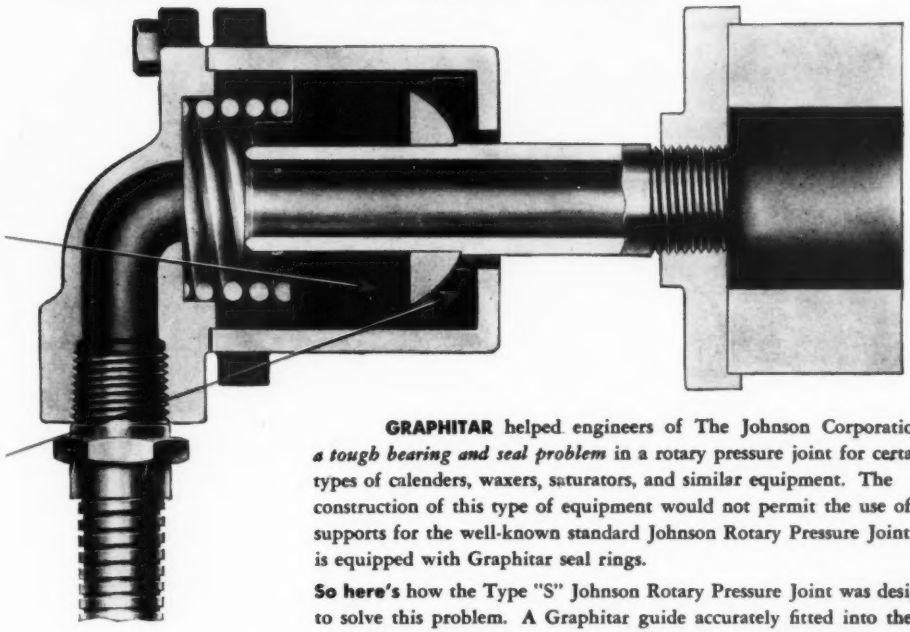
the Johnson Corporation uses Graphitar

GRAPHITAR may hold the answer to one of your design problems. It is mechanically strong, chemically inert, and highly resistant to wear. It is virtually unaffected by temperature extremes, it's self-lubricating, and extremely light weight. We can mold Graphitar in *a variety of shapes and sizes and finish it to tolerances as close as .0005" in small sizes.* Send us sketches or prints of your products and our engineers may show you where Graphitar will improve mechanical performance and save you money. **Ask for our new 64 page Catalog just released.**

THE UNITED STATES GRAPHITE COMPANY

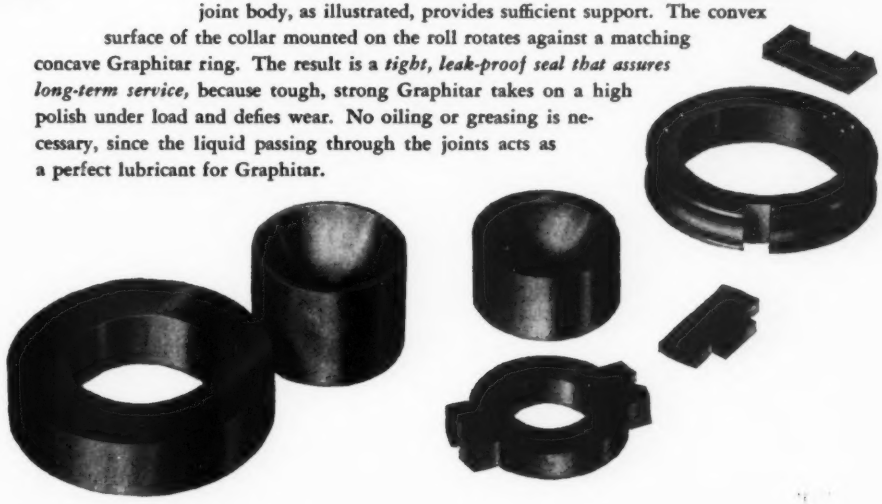
provides answer to design joint

Guide and Seal in Type "S" joint



GRAPHITAR helped engineers of The Johnson Corporation *lick a tough bearing and seal problem* in a rotary pressure joint for certain types of calenders, waxers, saturators, and similar equipment. The construction of this type of equipment would not permit the use of supports for the well-known standard Johnson Rotary Pressure Joint which is equipped with Graphitar seal rings.

So here's how the Type "S" Johnson Rotary Pressure Joint was designed to solve this problem. A Graphitar guide accurately fitted into the joint body, as illustrated, provides sufficient support. The convex surface of the collar mounted on the roll rotates against a matching concave Graphitar ring. The result is a *tight, leak-proof seal that assures long-term service,* because tough, strong Graphitar takes on a high polish under load and defies wear. No oiling or greasing is necessary, since the liquid passing through the joints acts as a perfect lubricant for Graphitar.



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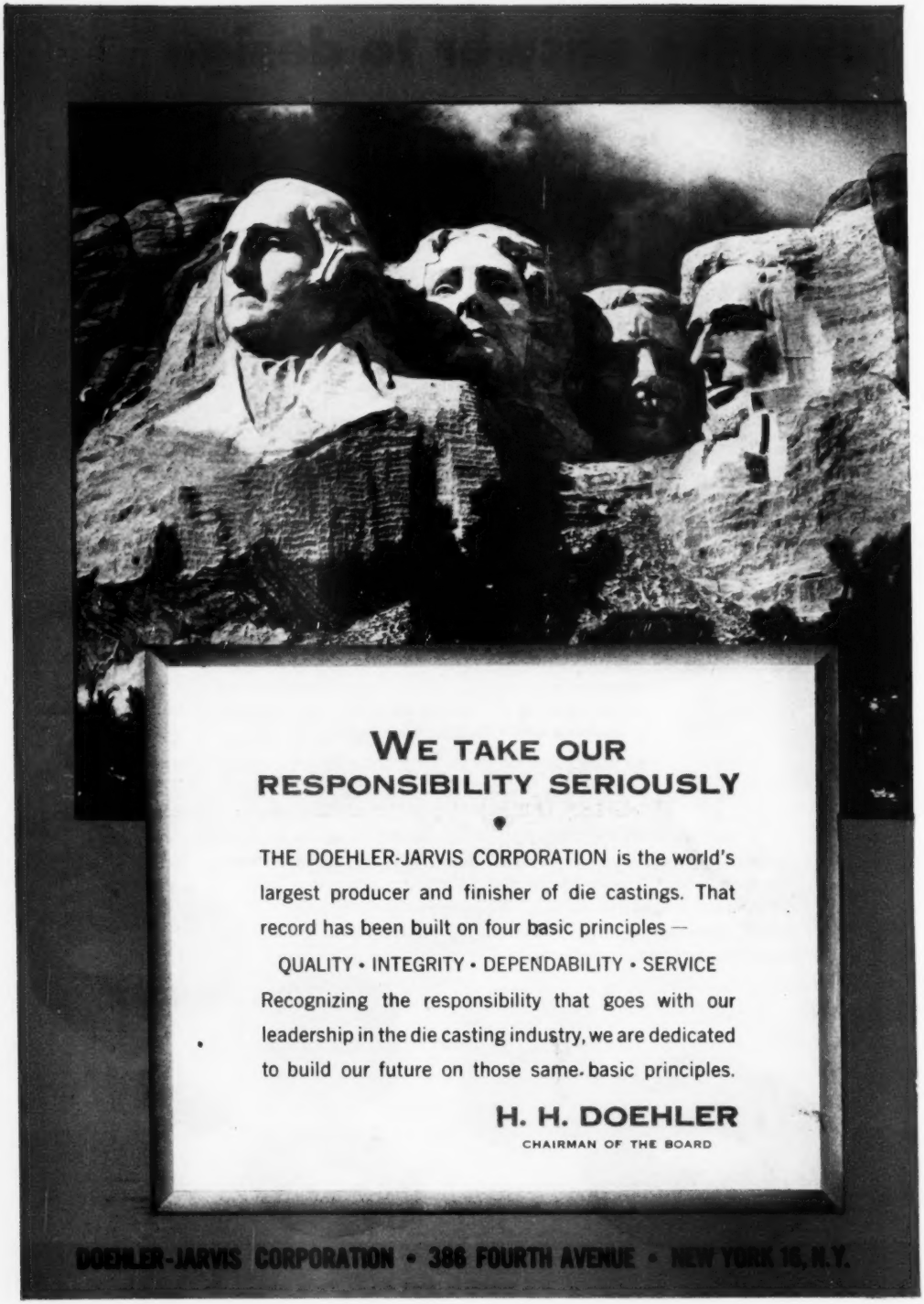
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RESPONSIBILITY SERIOUSLY
THE DOEHLER-JARVIS CORPORATION is the world's largest producer and finisher of die castings. That record has been built on four basic principles —
QUALITY • INTEGRITY • DEPENDABILITY • SERVICE
Recognizing the responsibility that goes with our leadership in the die casting industry, we are dedicated to build our future on those same basic principles.
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CHAIRMAN OF THE BOARD
DOEHLER-JARVIS CORPORATION • 386 FOURTH AVENUE • NEW YORK 16, N.Y.

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DESIGN for better living!

• New beauty, convenience, economy has been made possible through the use of plastics and metal and plastic combinations. The modern automobile has demonstrated this great potential. And the broad scope of the varied applications is being repeated again and again throughout industry.

Here under one roof at Auto-Lite's great Bay Manufacturing Division in Bay City are the technical skills and production capacity for a new art rendered in plastics. The artistic skill of Auto-Lite's Art and Style Division is available on matters of design and development.

THE ELECTRIC AUTO-LITE COMPANY

Bay Manufacturing Division

723 New Center Bldg., Detroit 2, Michigan • Bay City, Michigan

Auto-Lite

plastics and metals

"They're both good products

...but I'll take the one that can COUNT!"

ALL other points being equal, sales are often settled by one product's *extra* usefulness... such as the *ability to count*.

That's why a Veeder-Root Counter, *built into your product as an integral part*, is plainly good business . . . a hefty punch in today's slugfest for sales.

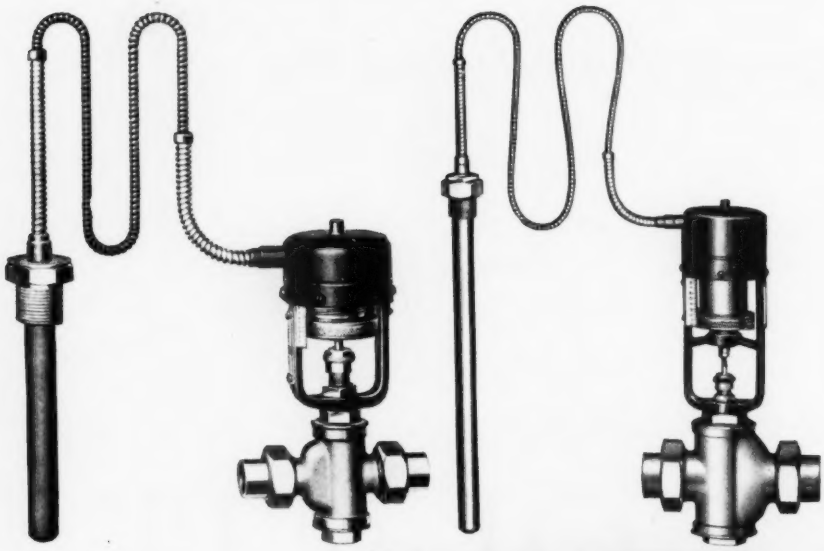
There are all kinds of Veeder-Root Counters, mechanical and electrical, to count in all units and terms . . . to enable your product to keep its own production records, prove its own service guarantee, and to give your customers protection in many ways against errors, delays, and waste. If there is *any* sales-building way in which your product can be equipped to count . . . then you can *count on Veeder-Root* to show you how. Write!

8-PAGE CONDENSED CATALOG shows Veeder-Root Counters for mechanical, electrical and manual operation. Write for a free copy.

Veeder-Root COUNTERS

VEEDER-ROOT INC., HARTFORD 2, CONNECTICUT

In Canada: Veeder-Root of Canada, Ltd., 955 St. James Street, Montreal 3. *In Great Britain:* Veeder-Root Ltd., Kilspindie Road, Dundee, Scotland.



No. 921 (left), No. 923 (right)—two representative regulators of the Fulton Sylphon line . . . a line that meets practically all temperature control needs.

For top performance...

Complete your equipment ...with SYLPHON TEMPERATURE REGULATORS

If you manufacture processing equipment or other machines involving temperature control, you can insure your product's performance at its best by using Sylphon Temperature Regulators as standard equipment.

These self-operated, simply constructed regulators help any apparatus requiring accurate, dependable temperature control to perform better, longer, and more economically. They help save possible "troubles" for you *and* your customers . . . give you an *extra* sales advantage. And—they're backed by Fulton Sylphon's 45 years' successful experience in this specialized field.

Widely used on cookers, washers, dryers, tanks, plating machines, slashers, dyeing machines, water-cooled engines, oil treaters . . . to name a few typical examples.

Find out how rugged, reliable Sylphon Regulators can help improve your product or perfect a new one. Send for Catalog NP-A that illustrates and describes the complete Sylphon line. It may spark profitable ideas for you.

Temperature Controls • Bellows Devices • Bellows Assemblies

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ROBERTSHAW-FULTON CONTROLS CO. KNOXVILLE 4, TENN.

Canadian Representatives, Darling Brothers, Montreal

with WHITNEY Roller Chain Drives

Delivery constant, full power from driver to driver mechanisms . . . that's one of the major advantages of using chain drives.

Deeply seated in the sprocket, Whitney Roller Chain eliminates power loss because there is no slippage or friction loss. This means that full rated horsepower is delivered . . . constant speed maintained . . . highest transmission efficiency always obtained.

In addition, Whitney Chain absorbs shock loads without breakage, assuring long operating life; while the flexibility and adaptability of chain drives simplifies design problems.

For positive power transmission specify and use Whitney Roller Chain . . . the *all steel drive*. Write for information.

CHAIN DRIVE IS BETTER

- Positive Grip
- Transmission of full horsepower
- High resistance to shock loads
- High load carrying capacity
- Simplifying transmission designs
- Low Maintenance
- Ease of installation
- Long operating life
- Constant uniform speeds

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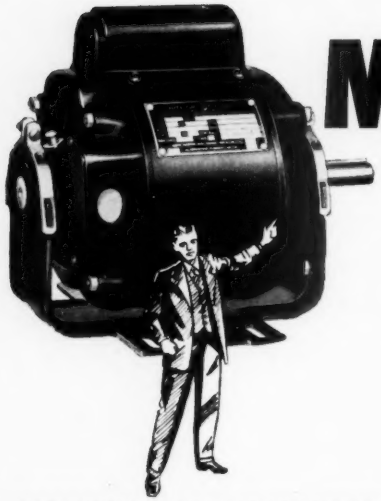

MOTOR FACTS

If You Have Applications for Motors, 1/20 to 5 H. P., You Can Use One or More of These Practical Data Bulletins

Here's motor information that Electrical Engineers and Appliance Manufacturers can *use!* Packed with pertinent specifications, construction details, and performance data, these Emerson-Electric Motor Bulletins furnish an authoritative reference guide in the selection of motors best suited to your applications. Emerson-Electric Motors are built to NEMA dimensional and operating standards. A request on your letterhead will bring you the Bulletins desired.

Write: The Emerson Electric Mfg. Co., St. Louis 21, Mo.

No. 110-F

CAPACITOR-START MOTORS

Complete information on a full line of general-purpose motors from 1/6 to 3/4 H.P. Suitable for many types of pumps, compressors, machine tools, blowers, and other applications requiring a single-phase fractional H.P. motor.

No. 111-F.

SPLIT-PHASE MOTORS

Specifications and construction features of both general- and special-purpose motors for a host of applications. Sleeve- or ball-bearing types; totally enclosed or open-protected; rigid or resilient mountings; thermal protectors. Ratings from 1/20 to 1/3 H.P.

No. 112-F.

INTEGRAL MOTORS

Emerson-Electric Integral Motors up to 5 H.P. are fully described, with construction details, performance curves, and dimensional data. Included are repulsion-induction, repulsion-start induction run, polyphase, and D.C. motors for a wide variety of applications.

FAN-DUTY MOTORS

America's leading fan manufacturer furnishes reliable finger-tip information on a complete fractional H.P. motor line, specially designed for applications with a fan blade mounted directly on the motor shaft. Single- and two-speed split-phase, split-capacitor, polyphase, and D.C. types, with specifications.

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OIL-BURNER MOTORS

Performance curves, dimensional data and construction features on specially designed oil-burner motors, based on 58 years of research, design and precision manufacturing to meet the problems of oil burner applications. Totally enclosed, streamlined, quiet-running . . . built for continuous trouble-free service. 1/6 H.P.

No. 114-F.

JET PUMP MOTORS

This bulletin gives construction features, performance curves and dimensional data on motors developed especially for direct-drive jet pumps. The heart of a jet pump is the motor that powers it . . . an important reason for specifying motors that embody every dependable feature and design improvement achieved by a pioneer manufacturer of pump motors.

No. 115-F.

EMERSON ELECTRIC

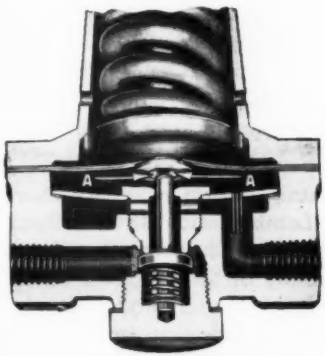
MOTORS • FANS • APPLIANCES

New

Norgren Relieving Type Regulator

holds pressure without "creep"

1. Performance exceeds that of many larger, more expensive relieving type regulators having larger diaphragms and valve ports.
2. Positive protection against "creep."
3. Permits downward adjustment of pressure without "bleeding" the line.
4. Eliminates damage to air equipment due to pressure surges.
5. Improves air equipment performance. Reduces wear and repairs.
6. Baffle plate and Syphon Tube permit *greater air flow with less pressure drop.*
7. Responds faster to changes in secondary pressure.
8. Prevents faulty performance due to out-of-line regulating springs.
9. Simple maintenance.—Can be easily and quickly disassembled without removing from the line.



THE NEW BUILT-IN RELIEF VALVE

The lower spring rest contains the valve opening lettered "A" and rests on a ball-end valve pin. When air pressure in the diaphragm area exceeds the regulated pressure, the lower spring rest containing the valve opening is raised from the valve pin permitting air to be released into the bonnet and out the breather holes. The lower spring rest automatically adjusts itself to any eccentricity due to out of line regulating spring—an exclusive Norgren feature.

Norgren

C. A. Norgren Co.,
222 Santa Fe Drive.
Denver 9, Colorado.

Lubricators, Regulators, Filters, Valves, other Air Controls, Hose Assemblies.

Weaver uses Houghton packings to give your car a "lift"

Service stations no longer have to excavate to install a lift for cars they lubricate. The new Weaver Twin Floor Lift is installed right on the garage floor at any convenient place, and will raise cars and light trucks hydraulically by the mere turn of a lever. The hydraulic cylinders are smaller and require less pressure than did the old style lifts, due to design change.

VIM Leather Cup Packings are used to hold the pressure. These packings, properly impregnated, moulded and trimmed to accurate size, can be depended on to maintain a tight seal against pressure loss.

Machine designers everywhere rely on VIM Leather and VIX-SYN Synthetic Rubber Packings because they know both the reliability of the products and the invaluable engineering service, freely provided. Have *you* a design problem? Put it up to E. F. HOUGHTON & CO., 303 W. Lehigh Avenue, Philadelphia 33, Pa.

HOUGHTON'S VIM LEATHER and VIX-SYN PACKINGS

What new applications new products can you make with truly boilable CEREX?

Collars and caps molded of Cerex by Popular Plastic Products Corp., Northport, N. Y., for The Delore Corporation, 32 W. 22nd St., N. Y. C.

Here's a happy item . . . new, sanitary, disposable baby bottles, vital parts of which are molded of Monsanto's *high heat-resistant* (108-112° C.) thermoplastic molding compound, CEREX.

Cerex's unique combination of high heat distortion, (it can be boiled over and over) dimensional stability, and added strength characteristics make it ideal for this product.

And Cerex gives you a similar ground floor opportunity . . . to introduce new products, heretofore impractical with ordinary plastics or other raw materials . . . to improve old products, give them new performance standards, new selling features.

Possible applications of Cerex are almost unlimited: Household merchandise, electrical components, surgical and medical appliances, industrial applications, etc.

Priced for commercial use, Cerex can be molded on standard injection machines, may be extruded, is machineable.

Write *today*, or send the coupon for full information on Monsanto's Cerex. Cerex: Reg. U. S. Pat. Off.

JUST REMEMBER: You get a bigger dollar's worth when you buy Monsanto Plastics.

CEREX Data Chart

Property	Average Value
Molding Quality	Good
Injection Molding Temp. (°F)	375-575
Injection Molding Pressure (psi)	10,000 up
Specific Gravity	1.04-1.06
Flexural Strength (psi)	10,000-15,000
Flexural Deflection (inches)	0.20-0.30
Tensile Strength (psi)	7,000-10,000
Elongation (%)	1.5-2.5
Impact strength (ft. lbs./in.) Izod (notched)	0.25-0.35
Heat Distortion (oil bath—°C)	108-112
Dielectric Constant @ 1 Mc	2.55-2.65
Dielectric Strength (step by step—volts/mil)	400
Power Factor @ 1 Mc	.0001-.0005
Rockwell Hardness	M70-M80
Water Absorption (24 hrs. —%)	0.04-0.08
Chemical Resistance	No effect from weak acids and bases or strong bases. Strong oxidizing acids attack.
Solubility	Soluble in esters, aromatics, higher alcohols and chlorinated hydrocarbons.
Clarity	Slight haze
Color Possibilities	Almost unlimited

Values determined under appropriate A.S.T.M. methods.

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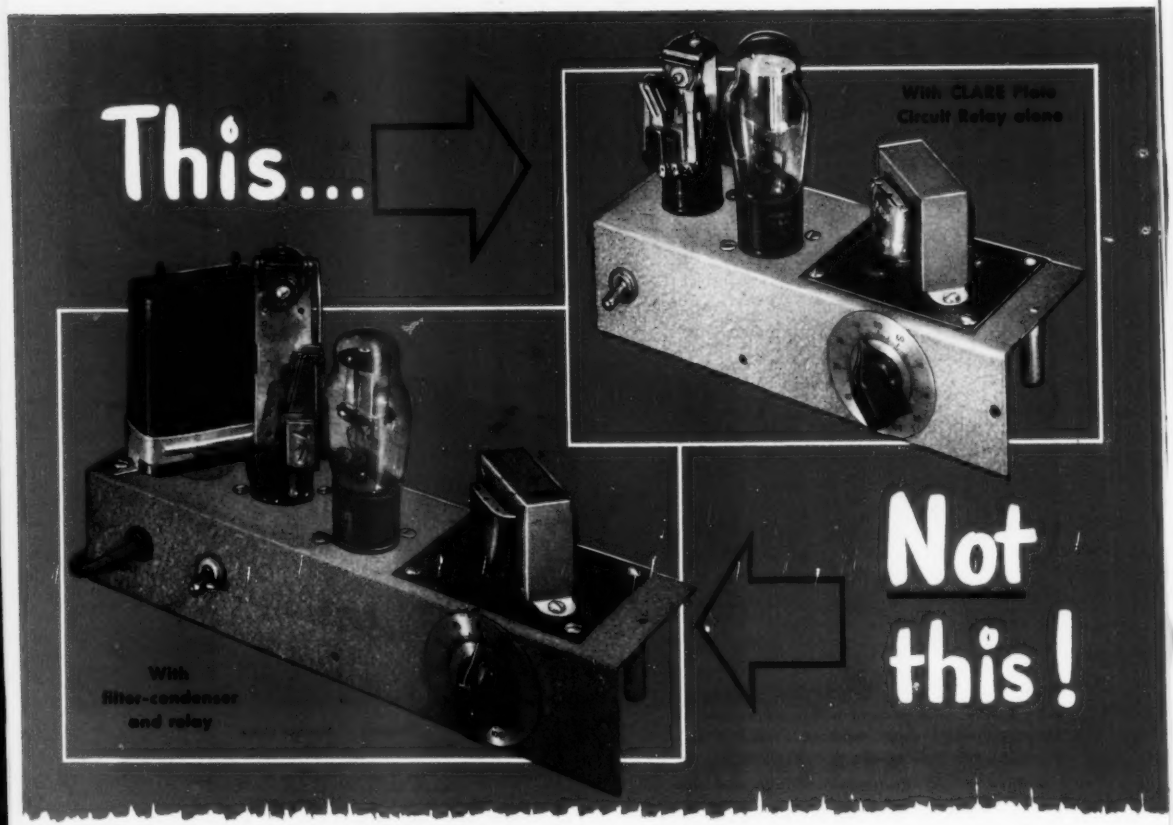
Please send me information on Cerex.
Name Title
Company
Address
City Zone State

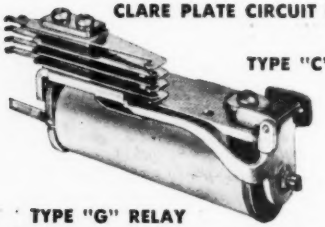
SERVING INDUSTRY . . . WHICH SERVES MANKIND

One CLARE RELAY will do the work...

of a Relay and Filter-Condenser in Many Plate Circuit Installations

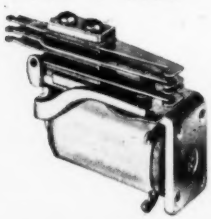


THREE SIZES AND TYPES OF CLARE PLATE CIRCUIT RELAYS

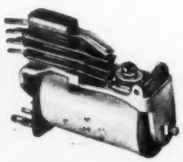


TYPE "C" RELAY

TYPE "G" RELAY



TYPE "J" RELAY



Utmost simplification of many plate circuit installations is possible with CLARE Plate Circuit Relays which make unnecessary the use of filter-condensers with or without induction networks.

By thus reducing the number of circuit elements, these CLARE Relays often make possible real savings of weight, wiring and cost.

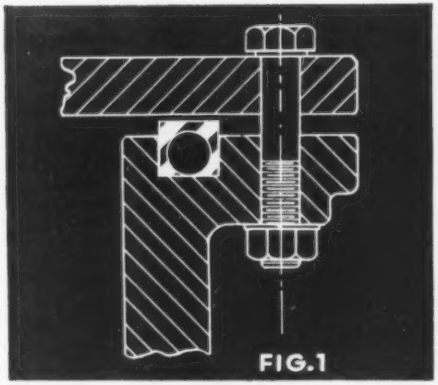
If your design involves plate circuits, it will pay you to get full information at once. CLARE sales engineers are located in principal cities. You are invited to make use of their wide experience in every problem which involves the use of relays. Call them today, or write: C. P. Clare & Company, 4719 West Sunnyside Avenue, Chicago 30, Illinois. In Canada: Canadian Line Materials Ltd., Toronto 13. Cable Address: CLARELAY.

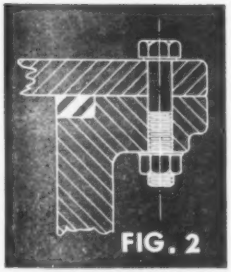
Write for Clare Bulletin No. 104

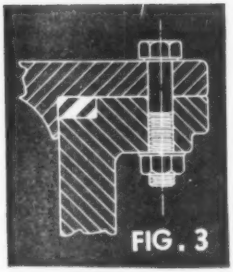
CLARE RELAYS

First in the Industrial Field

How to reduce sealing costs with truly compressible gaskets







Sealing costs often can be reduced by using truly compressible gaskets instead of special-section molded parts. Truly compressible gaskets usually are lathe-cut or die-cut to shape. Thus costly molds are eliminated and gasket-forming costs are reduced. And since these gaskets permit wider tolerances on recesses and mating parts, the cost of fabricating and assembling metal parts may be likewise reduced.

One such application is shown in figure 1. To illustrate why truly compressible gaskets permit wider metal tolerances, it shows the relative size of a round section, noncompressible ring and the equivalent truly compressible gasket made of Armstrong's cork-and-rubber. Compressing the extra thickness of cork-and-rubber obviously would compensate for much wider tolerance variations in metal parts.

The application in figure 2 utilizes the counterbore design to reduce fabricating costs. When molded rubber rings were tried, they tended to creep out of position. Cork-and-rubber, on the other hand, deforms mostly in the direction of the applied load. Hence, it remains firmly seated and provides an effective seal.

This type of construction can also be used to seal high internal pressures when altered as shown in figure 3. The controlled sideflow of cork-and-rubber provides a tight seal on both side and top. And the wider tolerances that are possible with Armstrong's cork-and-rubber rings hold sealing costs to a minimum.

Armstrong's cork-and-rubber can be made with natural or synthetic rubber. By adding calculated amounts of compressible cork to these noncompressible rubbers, Armstrong produces compounds in which sideflow is held within specified limits.

Versatile cork-and-rubber can help reduce your sealing costs. We suggest that you discuss your application with an Armstrong representative. He can suggest suitable materials and supply samples for your experimental use.

Send for this Gasket Handbook

You'll find useful application and specification data in the new, enlarged 24-page booklet, "Armstrong's Gasket and Sealing Materials." It contains up-to-date data on synthetic rubber, cork-and-synthetic-rubber, cork composition, and fiber sheet sealing materials.

This booklet includes ten technical discussions of the factors influencing modern gasket and joint design. It also suggests methods of putting Armstrong's stock materials to specialized uses in such fields as radio, electrical, automotive, petroleum, and transportation industries. Also included are typical applications and current government specifications.

For your free copy, fill in coupon at right and mail today.

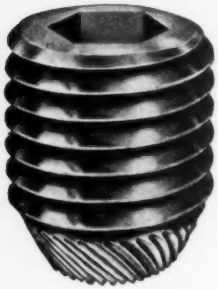
ARMSTRONG'S
GASKETS · SEALS · PACKINGS

Cork Compositions • Cork-and-Synthetic-Rubber Compositions
Synthetic Rubber Compounds • Cork-and-Rubber Compositions
Fiber Sheet Packings • Rag Felt Papers • Natural Cork

ARMSTRONG CORK CO.
Gaskets and Packings Dept.
7107 Arch Street, Lancaster, Pa.

Please send me at once a copy of the new 24-page booklet, "Armstrong's Gasket and Sealing Materials."

NAME .....
COMPANY .....
ADDRESS .....
CITY ..... STATE .....



The patented Knurled Cup Point of this popular "UNBRAKO" Socket Set Screw makes it a Self-Locker, because the edges of the counter-clockwise knurls positively prevent creep, regardless of the most chattering vibration. *"It won't shake loose!"*
Pat. & Pats. Pe'd

The patented Knurled Threads of this "UNBRAKO" Socket Set Screw are swaged—making it a most excellent Self-Locker for applications requiring cone, oval, flat or other points except cup, and for use with hardened shafts. *"It won't shake loose!"* *

UNBRAKO

SELF-LOCKING SET SCREWS

KNURLING MAKES THESE SET SCREWS "STAY PUT"

"...They Won't Shake Loose"—that's why more and more manufacturers are specifying these screws to reduce downtime and repair costs... to increase production, speed deliveries and protect customer goodwill.

Their exclusive *knurling* makes them exceptionally vibration-resistant, prevents "creep" and subsequent loosening of the screws. They "stay put", even under the most chattering vibration.

UNBRAKO *Self-Locking* Set Screws can be real "Vibration Insurance" for *your* production machinery. And remember, they make an impressive selling point when you use them on your finished products. Our folder 658-1 gives you further details. Write for yours today!

Knurling of Socket Screws originated with "Unbrako" in 1934.

**These screws are not carried in stock. Prices are available on application.*

SPS

STANDARD PRESSED STEEL CO.

BOX 545 JENKINTOWN, PENNSYLVANIA

"Serving Industry continuously since 1903 through Industrial Distributors"

Record-breaking NICHROME* V Belt serves 7,000 hours at 2050°F. in Copper Brazing Furnace!

Delivery end of electric copper brazing furnace operated by National Stamping Company—brazed steel parts being delivered by continuous-mesh Nichrome V Belt.

BELT SPECIFICATIONS
length: 98' 6"
width: 20"
mesh : 3/8"
wire : 12 gauge Nichrome V

. . . actual life of this belt extended for many thousand hours more (a large percentage of the time at steel annealing temperature of 1840°F.), but its long service at 2050°F. makes its performance outstanding . . . in fact, puts this belt "at the head of the class."

For though wire belts may last, according to an internationally recognized furnace manufacturer, "practically forever" at lower temperatures such as 1300°—1400°F.—often employed for considerable periods in furnaces of this type—their useful lives are measured by service rendered under heat at 2050°F.

ALL KNOWN RECORDS BROKEN

Says Ashworth Bros., Inc., maker of the belt: "This Nichrome V wire belt was installed in a modern electric copper brazing furnace and operated at the Detroit plant of National Stamping Company from June 1, 1947 to September 24, 1948. Its history, including approximately 7,000 hours at 2050°F. under full load, indicates ***it broke all records for this type of service.***"

MORE OUTSTANDING FACTS

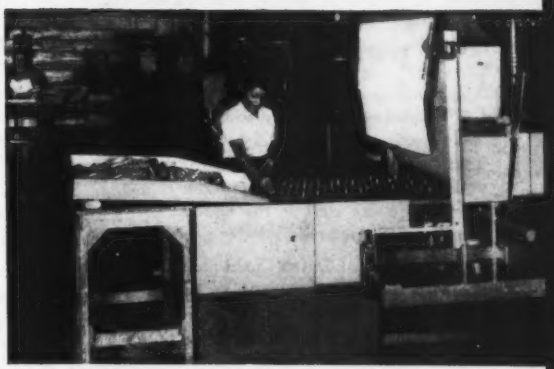
Further information only emphasizes the noteworthy performance of this veteran piece of furnace equipment. For example:

(a) Belt Size—belts of this size, 98' 6" long x 20" wide, must be exceptionally stable to give such long and efficient service.

(b) Production—approximately 380 lbs. of work were handled per hour.

YOUR HEAT-TREATING PROBLEMS AND DRIVER-HARRIS

In selecting *your* heat-treating equipment, remember the outstanding ability of Nichrome V to give top-level performance at high temperatures, such as that of copper brazing. And remember, too, that Driver-Harris has been engaged in finding the correct answers to furnace problems for more than 35 years. Our accumulated experience and unique specialized knowledge will help you to lower operating costs, reduce maintenance, minimize repairs, increase production.



Feed end of furnace—parts being placed on Nichrome V belt (This belt supplied by Ashworth Bros., Inc., Worcester, Mass.)

50TH YEAR — SPECIAL PURPOSE ALLOYS SINCE 1899 — D/H — TRADE MARK REG. U.S. PAT. OFF. — 1899 - 1949

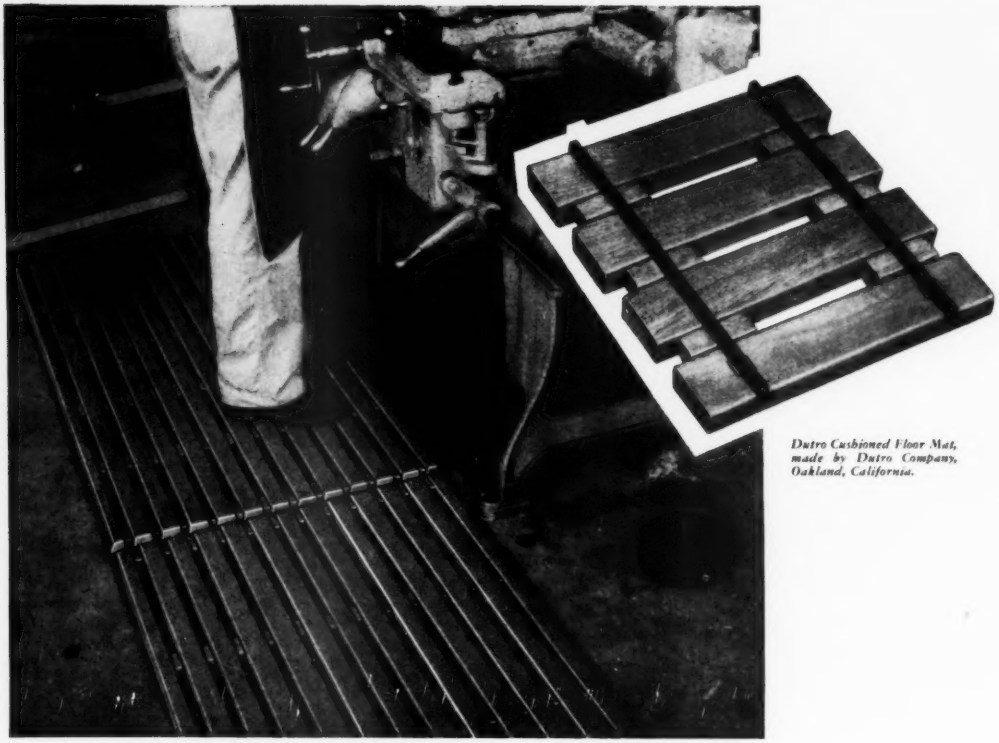
Nichrome is manufactured only by

Driver-Harris Company

HARRISON, NEW JERSEY

BRANCHES: Chicago, Detroit, Cleveland, Los Angeles, San Francisco, Seattle

*T.M. Reg. U.S. Pat. Off.



Dutro Cushioned Floor Mat, made by Dutro Company, Oakland, California.

It puts a cushion under foot—lowers expense too!

THESE floor mats used to lead a rough, and often a short life. The rubber binding strips on the underside wouldn't stand up under hard usage—as well as the effects of oil, grease or acid.

The makers of Dutro Cushioned Floor Mats, after tests of many rubber compounds, found that Hycar American rubber not only solved the problems, but gave them *extra* advantages.

For example, mats have been in use for three years and Hycar is still doing a first-rate job! It acts as a resilient cushion—helping reduce worker fatigue. Mats do not come apart or stretch out of shape. They protect dropped tools and parts.

These floor cushions are paying for themselves many times over in machine shops, canneries, restaurants, locker rooms and other "problem spots" where service conditions are severe.

Hycar American rubber set the pace here, as it has in so many other products, because of its versatility. It resists heat and cold, weather and wear. It's light in weight, has high tensile strength, is highly resilient. It's oil-resistant—gas-resistant. Compounds can be varied from extremely soft to bone hard, and can be made in many colors.

Hycar
Reg. U. S. Pat. Off.
American Rubber

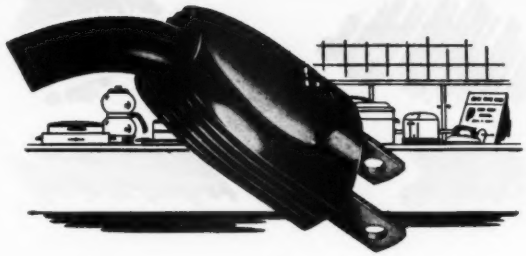
Besides being a base material, Hycar may be used as a plasticizer . . . as a modifier for phenolic resins . . . as an adhesive . . . as a latex for coating or impregnating.

Hycar is used in practically every field, in dozens of ways. Perhaps it may answer your problem—improving a product or developing a new one. For complete information and helpful service, please write Dept. HJ-7, B. F. Goodrich Chemical Company, Rose Building, Cleveland 15, Ohio.

B. F. Goodrich Chemical Company
A DIVISION OF THE B. F. GOODRICH COMPANY

GEON polyvinyl materials • HYCAR American rubber • GOOD-RITE chemicals and plasticizers

Wiring Components FOR PRODUCT DESIGN



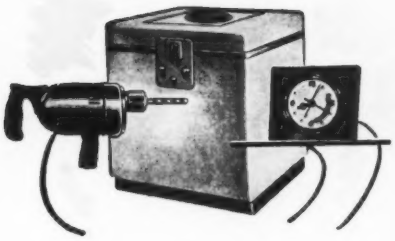
COLORFUL EYECATCHER ADDS EXTRA APPEAL

To help build sales for your product, General Electric cord sets are now available with the tough, attractive G-E "400" plug. Cord sets displaying this colorful new plug give your product that little extra up front where the competition is the keenest—right on the counter—at the point of sale.

- **Red, gray, black, or brown color**
- **One-piece plastic, molded-on-cord**
- **Strong, solid brass blades**
- **Smooth, high-gloss surface**
- **Bell-mouth opening at heel and permits free movement, increases cord life.**

Teamed with the new General Electric Preen-X heater cord, the "400" plug makes an attractive cord set for heating appliances. When used with other cords in the General Electric line, this "400" plug offers an opportunity to add a distinctive feature to electrically-powered tools, machines, and appliances. G-E cord sets with the "400" plug provide an extra talking feature—an extra selling point.

Why not see what a General Electric cord set with a "400" plug can do for your product? Just check "A" in the coupon.



SIMPLIFY YOUR SELECTION OF POWER SUPPLY CORDS

For household appliances, for machine-shop tools—for light-, medium-, and heavy-duty equipment—simplify your problem of cord selection by standardizing on General Electric Flamenol* cords.

These tough cords have what it takes to withstand the effects of household or machine-shop abuse. They have a smooth, easily-cleaned, thermoplastic jacket that's as hard-wearing as it is good-looking. It is resistant to water, oils, alkalies, sunlight, and acids, yet it's flexible, strong, and easy to handle.

Do you have a power cord problem—would you like to know more about General Electric portable cords? Just check "B" in the coupon below.

HERE'S THE NEWEST HEATER CORD IDEA

Consumer-tested and approved — this new General Electric Preen-X heater cord offers designers something excitingly new in a heater cord—with practical advantages over old-type heater cords.

This amazing new cord is of rip cord construction, with one conductor marked by an identifying rib. It's easy to rip, easy to strip, easy to connect. It's available in either black or brown color, and is listed by Underwriters' Laboratories, Inc.

Preen-X heater cord defies abrasion and annoying kinking—actually has more than *ten times* the abrasion resistance of ordinary, braided cords.

Preen-X heater cord is water-, oil-, and grease-proof. It's good-looking, too—the smooth, flexible jacket rejects lint, resists soiling.

For more information on this brand-new, General Electric cord—Preen-X heater cord—check "C" in the coupon.

General Electric Company, Section L4-767
Construction Materials Department
Bridgeport 2, Connecticut

Please send me, free, the items checked below:

- **A** ☐ **Information on the General Electric "400" plug**
- **B** ☐ **Information on General Electric portable cords**
- **C** ☐ **Information on new General Electric Preen-X heater cord**
- **D** ☐ **Information on the subject attached**

Name _____
Company _____
Title _____
Street _____
City _____ **Zone** _____ **State** _____

Trade-mark Reg. U.S. Pat. Off.

GENERAL ELECTRIC

yes... an oil seal that's tailor-made to *resist* corrosion

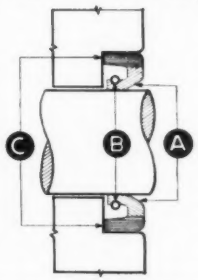
● If corrosive conditions are shortening the life of your oil seals, the Johns-Manville Clipper Seal should provide a practical solution to your problem.

Here's why: The Clipper Seal's molded body is entirely non-metallic and is, therefore, unaffected by most forms of corrosion. To meet special conditions, the garter spring which holds the lip in contact with the shaft can be furnished in various corrosion-resistant metals . . . *or Clipper Seals of special design that do not require garter springs may be used.*

The one-piece, concentric molded design of Clipper Seals also assures a number of other advantages. The hard, tough outer heel of the Clipper Seal is resilient enough to conform even to a slightly out-of-round cavity. And the soft, pliable inner lip always maintains a light, but positive sealing pressure on the shaft, with minimum wear on the seal.

Clipper Seals are quick and easy to install, may be had in split or endless types, are available in sizes from ¼″ I.D. up to 66″ O.D. If you have a special sealing requirement, or wish to consult about a special design problem, write Johns-Manville, Box 290, New York 16, N. Y.

Here's how *Clipper Seal* works:



The flexible lip (A) is held in light but firm contact with the shaft by means of the garter spring (B). Pressure on shaft is carefully pre-determined to minimize wear, yet effectively seal against leakage. The rigid heel (C) provides a press fit in the cavity, assuring a tight lubricant-retaining seal at this point also.

Johns-Manville **PACKINGS & GASKETS**

NEW MICRO Precision Switch

rating — 1½ Horsepower Motor at 230 Volts a-c.

UND. LAB. INC. INSP
20A125, 250, 460 VAC 10A125 VAC "L"
¾ H.P. 115 VAC
1½ H.P. 230 VAC
MICRO Type "F" Housing for Type "A" Snap Switch
MICRO SWITCH
CAT. NO.
FREEPORT, ILLINOIS, U.S.A.

In the new Type "A" Switch, MICRO SWITCH offers a small, lightweight, accurate switch to handle the high current inrush required in the operation of solenoids, motors and tungsten lamps.

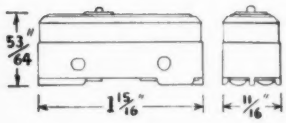
The MICRO Type "A" Switch is listed by Underwriters' Laboratories for 1½ H.P. motor, 230 volts a-c; ¾ H.P. motor, 115 volts a-c; 20 amperes, 125, 250 or 460 volts a-c; tungsten lamp, 10 amperes, 125 volts a-c. Rated for 75 amperes inrush capacity to 460 volts a-c.

If your design requires a small precise control switch which must take high current inrush throughout a long life . . . with no danger of welding or sticking . . . be sure you have all the facts on this new MICRO Type "A" Switch.

If your design calls for any kind of a small precision switch, MICRO SWITCH representatives can select from over 3900 variations of switches the one best suited to your needs. Call or write a MICRO SWITCH engineer at one of the offices listed below.

MICRO . . . first name in precision switches

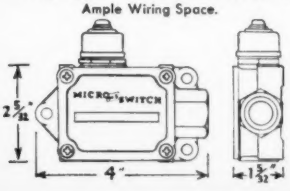
New MICRO Type "A" Switch



This small switch will handle a 1½ H.P. motor at 230 volts a-c. It is available with five different types of actuators.

Sturdy Type "F" Die Cast Housing

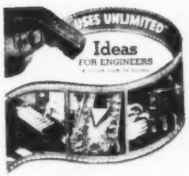
Ample Wiring Space.



This MICRO Type "F" die cast housing is designed for the high capacity Type "A" Switch. The synthetic rubber seal boot covers the operating plunger and resists the entrance of oil, moisture, dust, etc. Available in right and left hand designs.

"USES UNLIMITED"

A dramatic MICRO SWITCH 16 mm. sound motion picture in color, is available to industrial groups, training classes, schools and colleges. Running time, 35 minutes.



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MICRO SWITCH
A DIVISION OF FIRST INDUSTRIAL CORPORATION
FREEPORT, ILLINOIS, U.S.A.

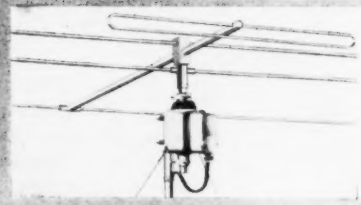
BRANCH OFFICES:
Chicago • New York • Boston • Cleveland • Los Angeles

SALES REPRESENTATIVES:
Portland • St. Louis • Dallas • Toronto

It pays to use your custom molder's know-how

say men who make television "beaming" devices

No. 7 in a series on Plastics Skill at Work . . .

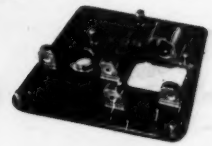


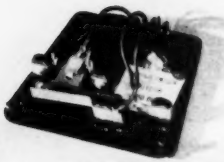
PROJECT: Two-piece control case to house transformer for antenna rotator.

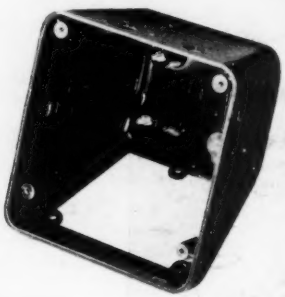
CUSTOMER: Alliance Manufacturing Co., Alliance, Ohio.

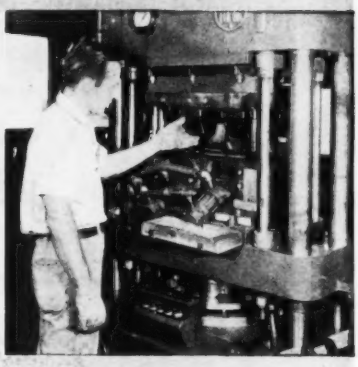
MOLDER: Evans-Winter-Hebb Inc.

MATERIAL: Economical general-purpose Durez phenolic plastic.









ECONOMY: Molder eliminates many operations by producing electronic control case and face plate with lugs, bosses, cutouts, and inserts all "molded-in."

SPEED: Two-cavity compression mold with hydraulic cylinders for coring holes maintains high output. Front panel is a four-cavity mold. Loose wedges form light bulb socket hole.

At first glance this control box looked like a straightforward job of molding. Yet a small design change suggested by the molder points up a fact that is gaining wide recognition these days...

The earlier you call in a first-class plastics man, the more you stand to gain by his experience.

In the *Tenna-Rotor*, Alliance Mfg. had developed a motor-driven TV and FM antenna rotation device that selects the exact compass point for optimum reception... strong signals, clear pictures. Armchair control was provided by a three-position switch in an attractive Durez plastic case.

Examining the blueprints, Evans-Winter-Hebb molding men saw eight tapped holes for mounting the transformer in the top of the control box. To provide a stronger and more durable and rigid mounting, they suggested that only four screw posts be used, and that these be molded into the Durez. Results: *one*, a more serviceable product, and *two*, a simplified assembly.

* * *

For specialized experience with phenolics, the most versatile of all plastics, your molder will welcome his Durez field man in your planning sessions. Call on us without obligation. We'll gladly serve you and him.

A new hit with plastics users everywhere is the handy "Durez Check-Chart." Write for yours. Durez Plastics & Chemicals, Inc., 157 Walck Rd., N. Tonawanda, N. Y.

DUREZ — PHENOLIC RESINS — MOLDING COMPOUNDS · INDUSTRIAL RESINS · PROTECTIVE COATING RESINS

PHENOLIC PLASTICS THAT FIT THE JOB

A Compact New Starter for Fractional Hp Motors

. . . that provides

Reliable

OVERLOAD PROTECTION

Open view of enclosure for surface mounting

Closed view of enclosure for surface mounting

Bulletin 600 Switch with waterproof enclosure

Bulletin 600 Switch fits any standard switch box

Here is a small, manually operated starter that will satisfy the latest ruling of the National Electrical Code . . . which requires overload protection for a great many fractional horsepower motor applications. The Bulletin 600 Starting Switch is built in the single- and double-pole construction, and is rated one horsepower and less. Its dependable thermal breaker trips the switch under a sustained overload, protecting the motor against burn-out. When the overload is cleared, the breaker is easily reset with the switch lever. However, the switch cannot be held closed so long as the overload condition remains.

The Bulletin 600 Starter is available in enclosures to meet every service requirement. Send for complete data. Allen-Bradley Co., 1316 S. Second St., Milwaukee 4, Wisconsin.

A-B Quality

ALLEN-BRADLEY

BULLETIN 600 STARTING SWITCHES

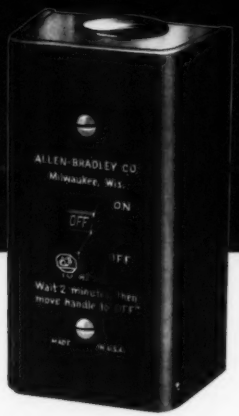
QUALITY

SEE OTHER SIDE

BULLETIN 600...

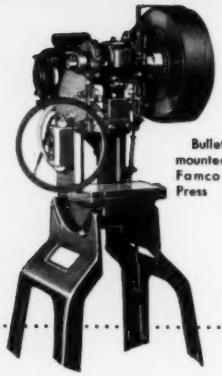
The Popular Starter for Machines Using Motors of 1 Hp or Less

Designed for Modern Requirements



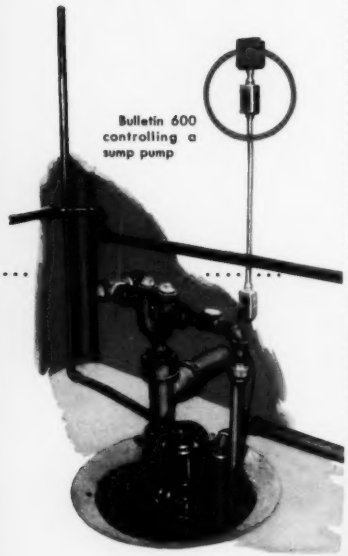
This reliable snap switch starter has been redesigned—inside and out—to provide more wiring space . . . more accessible terminals . . . and a far more attractive appearance on your machine.

Meets N.E.C. requirements and is a sales asset on any motorized machine.

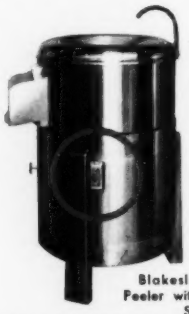


Bulletin 600 mounted on a Famco Power Press

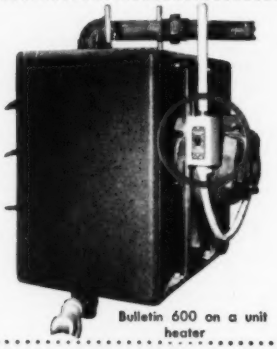
Triumph Cookie Dropper with Bulletin 600



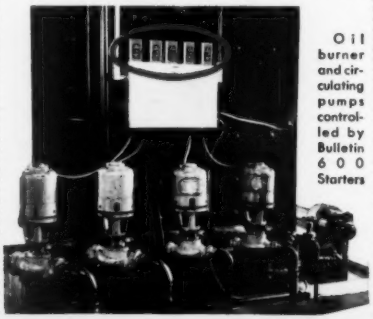
Bulletin 600 controlling a sump pump



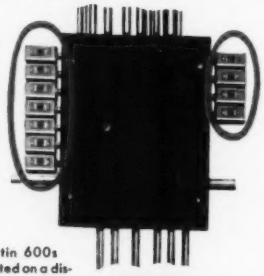
Blakeslee Vegetable Peeler with Bulletin 600 Starter



Bulletin 600 on a unit heater



Oil burner and circulating pumps controlled by Bulletin 600 Starters



Bulletin 600s mounted on a distribution panel

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NATIONAL OIL SEAL LOGBOOK

USE OF EXTERNAL-WIPE SYNTECH OIL SEALS FOR WHEELS AND SIMILAR APPLICATIONS

External-wipe National Syntech seals are ideally suited for front wheels of cars and light trucks; and for trailers, where wheels are removed and remounted frequently.*

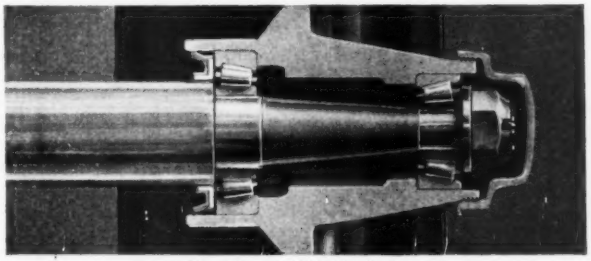

Figure 1—Typical Wheel Application

NEW external-wipe oil seals with synthetic rubber sealing members offer important advantages to automotive manufacturers. In many wheel applications, they facilitate assembly, make wheel removing and remounting easier, give zero-leakage, low-torque sealing and moderate cost.

An exceptionally good use of National Syntech external seals is the car trailer wheel (Fig. 1). Here the manufacturer requires long-wearing, zero-leakage seals that can be left on the hub when wheels are removed. New National 360,000 Syntech externals (Fig. 2) not only meet these requirements, but actually simplify wheel shifting. This is because (a) these seals press-fit onto the hub and are thus not moved when wheels are dismounted, and (b) sealing lips point inward, so remounting is completed *with* instead of *against* the sealing direction.

For superior sealing, these National Syntechs also have rubber-covered Inside Diameters. And their simplicity of design means a substantial saving to the manufacturer—better sealing at less cost!

For other mechanisms where extreme dust, dirt, heat or speed conditions exist, other new National external Syntech seals are available. For example, in high speed, high temperature applications (such as aircraft landing wheels, etc.) where centrifugal force is a factor, a spring-loaded external Syntech (Fig. 3) proves highly effective.

For complete information on new

Figure 2
Springless External Wipe Oil Seal

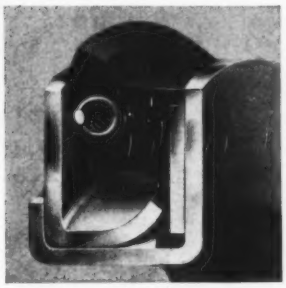

Figure 3
Spring-loaded External Wipe Oil Seal

National Syntech seals and their application to your product, consult the nearest National Oil Seal Engineer, or write direct to factory.

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RIGHT in their element . . .
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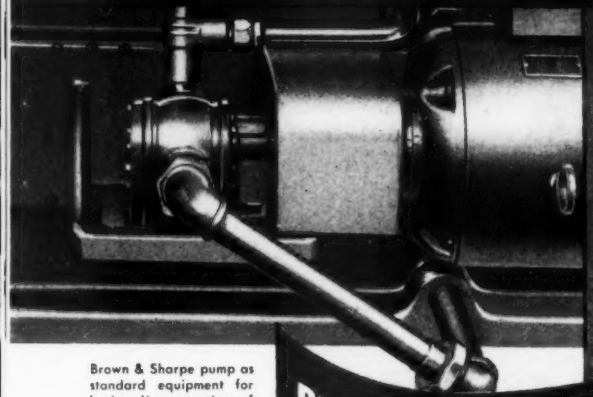
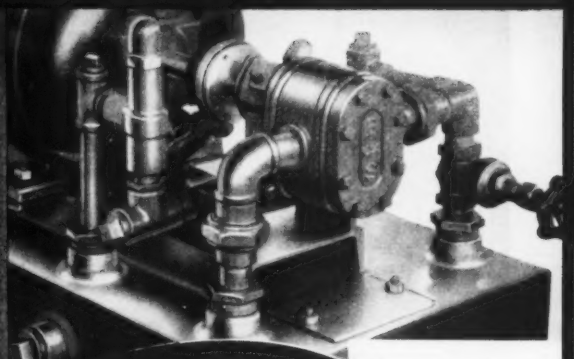
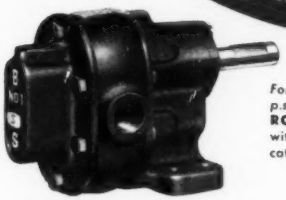


Brown & Sharpe pump as standard equipment for hydraulic operation of machine tool.



Compact installation of Brown & Sharpe pump for hydraulic operation of stoker unit.

BROWN & SHARPE Rotary Geared PUMPS



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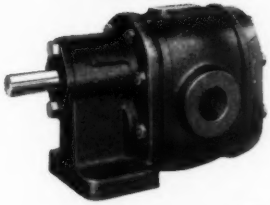
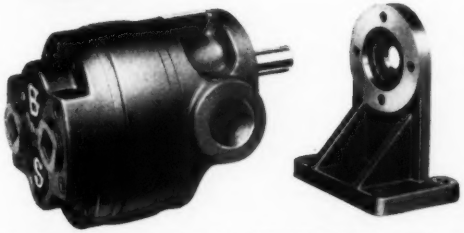


For pressures up to 200 lbs. p.s.i . . . **NOS. 53 and 55 ROTARY GEARED PUMPS** with roller bearings and helical gears.



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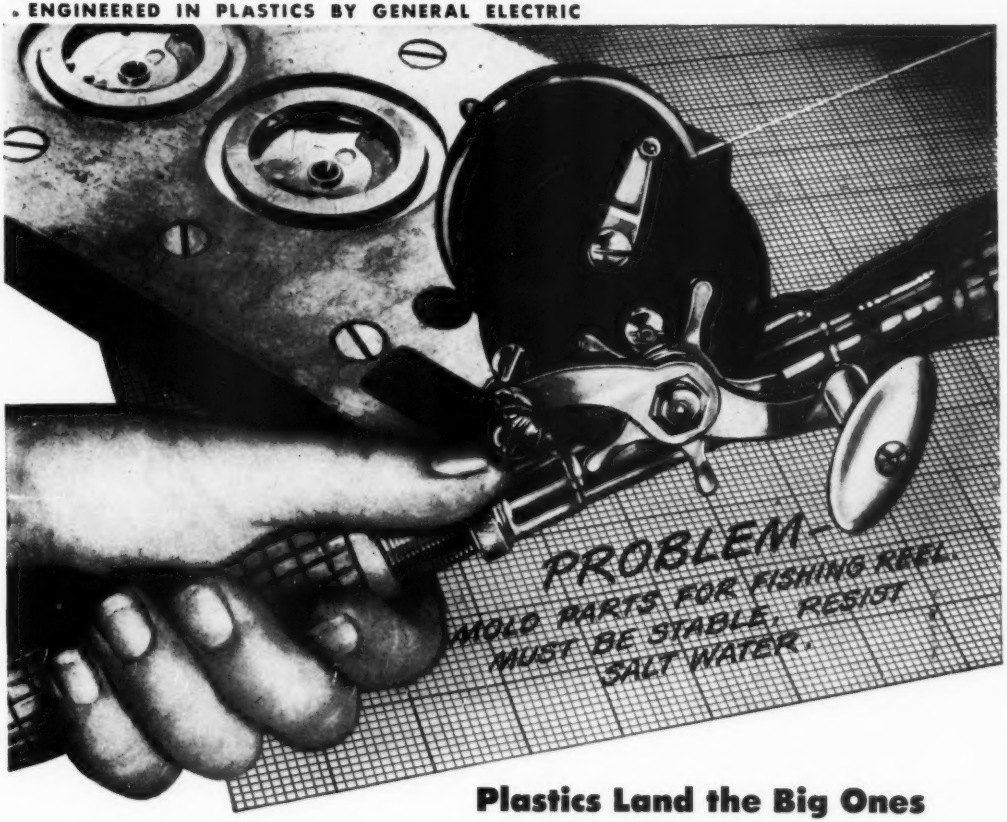

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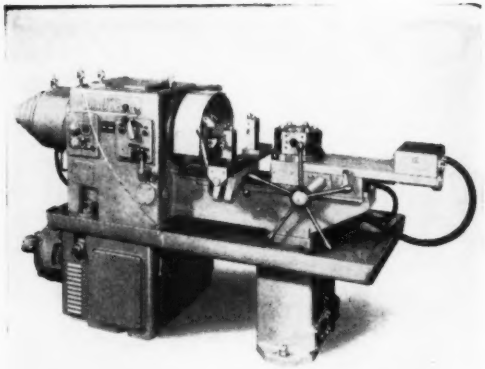

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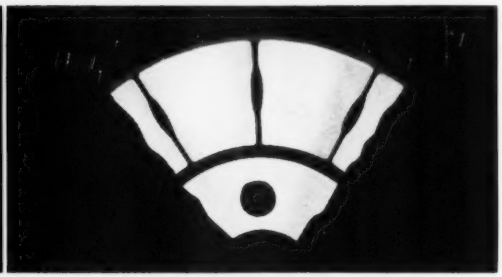

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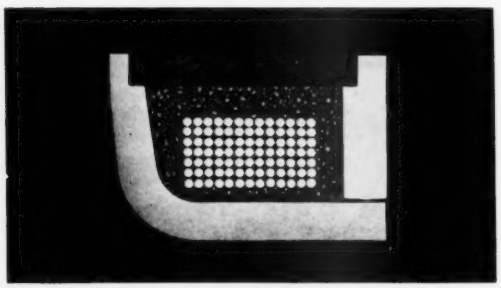

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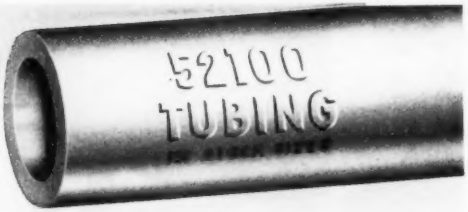

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No matter which analysis you choose you'll be sure of uniformity from tube to tube and order to order because every step in manufacture is controlled in the Timken Company's own mills. Write for free stock lists. The Timken Roller Bearing Company, Steel and Tube Division, Canton 6, O. Cable address: "TIMROSCO".

50th birthday of the company whose products you know by the trade-mark: TIMKEN

Specialists in alloy steel—including hot rolled and cold finished alloy steel bars—a complete range of stainless, graphitic and standard tool analyses—and alloy and stainless seamless steel tubing.

Who says it's man's work?

She knows (as you do)

Women like these lightweight lawnmowers. They make grass cutting easy and take plenty of knocks without breaking. They sell by the thousands because the price is right.

Alcoa Aluminum Die Castings established a sales preference in lawnmowers. They can do the same for your product. Improve its looks. Boost its performance. Lower its price. Now is the time to start planning. Ask your Alcoa sales office for the book "Designing for Alcoa Die Castings". Or write ALUMINUM COMPANY OF AMERICA, 611G Gulf Building, Pittsburgh 19, Pennsylvania.

She doesn't know (but you do)

With the ability of the Alcoa organization come important advantages of Alcoa Die Castings themselves. They do not "creep" nor "grow". They are excellent conductors of heat and electricity. Add these advantages to a bonus of light weight and a competitive price structure.

ALCOA ALUMINUM Die Castings merit your FIRST consideration

ALCOA FIRST IN ALUMINUM

ALCOA ALUMINUM

INGOT • SHEET & PLATE • SHAPES, ROLLED & EXTRUDED • WIRE • ROD • BAR • TUBING • PIPE • SAND, DIE & PERMANENT MOLD CASTINGS • FORGINGS • IMPACT EXTRUSIONS
ELECTRICAL CONDUCTORS • SCREW MACHINE PRODUCTS • FABRICATED PRODUCTS • FASTENERS • FOIL • ALUMINUM PIGMENTS • MAGNESIUM PRODUCTS

YOU CAN BE SURE.. IF IT'S

Westinghouse

Here's how Life-Line motors can save you half the upkeep cost, and more.

A recent survey of 114 large motor users—operating 131,626 a-c motors of 1 to 50 hp—shows how much motors *really* cost when you figure actual "Life Cost".

The survey shows that the yearly average cost of periodically lubricated motors was $270 for every hundred motors installed.

On lubrication cost alone, Life-Line motors saved this $270. That's because Life-Line requires no periodic lubrication—no added lubrication of any kind.

The survey also indicates that the yearly outage cost per hundred motors, for repairs and lost machine and man-hours, was $960.

The record of 500,000 Life-Line motors in service, to date, indicates a failure rate averaging less than half that of conventional motors covered by this survey. This means over 50% indicated reduction in motor outage costs—in short, a possible saving of $480 per year with Life-Line.

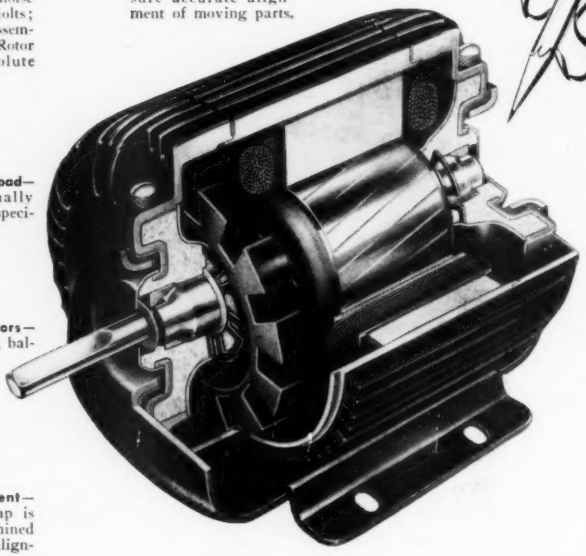
Add these savings—$270 for lubrication plus $480 for outages—and the result is $750 per hundred motors per year.

Can you afford to pass up savings like these? Get the facts on the savings possible in your plant. Ask your nearby Westinghouse representative for a copy of B-4321 "How to Cut Motor Costs $750". Or write Westinghouse Electric Corporation, P.O. Box 868, Pittsburgh 30, Pennsylvania. J-21514

Westinghouse *Life-Line* Motors

Take time to look...

...INSIDE



Controlled end play—Takes shock and noise out of end play jolts; allows precision assembly into your unit. Rotor remains at absolute magnetic center.

Rugged housings—Assure accurate alignment of moving parts.

H.P. rated at full load—Motors individually tested to assure specified h.p. rating.

Super-safe lubrication—Extra large reservoirs with recirculation of lubricant.

Flush surface rotors—For quiet, smooth, balanced operation.

Individually fitted bearings—Fitted to the shaft at .0001" tolerance, at clearance of .0005".

Accurate alignment—Concentric air gap is assured by machined frame and self-aligning bearings.

Precision field construction—Machine wound, varnish baked coils are highly resistant to oil and humidity.

Redmond MICROMOTORS

There's a lot of difference in today's electric motors.

Outwardly, they all conform pretty much to a general pattern for each particular type, size and purpose.

But the experienced buyer of motors knows that the *real character*—the *genuine worth*—of a motor lies beneath the outer shell.

That's why Redmond advises, "Take Time to Look Inside."

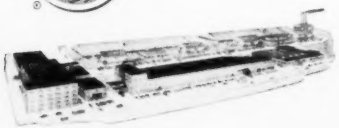
For Redmond Micromotors look better, the more they are examined, the more they are compared. Look inside a Redmond Micromotor and you will find a list of features unmatched by any other make.

Look inside and you will learn why Redmond Micromotors give you the smoothest, quietest, longest-lasting service you've ever known in an electric motor.

Yes, take time to Look Inside. You'll *see* the difference!

REDMOND

150 standard models, 25 types, up to 1/10th h.p. A.C. and D.C. Illustrated is the type "Y" A.C. Micromotor.



Redmond COMPANY, INC., OWOSSO, MICHIGAN

Offices in: New York, Chicago, Los Angeles, Dallas

Skillful molding tells a gripping story

Among mimeograph artists, the hand is now quicker—and so is the eye, thanks to these plastic stylus handles. Their carefully developed and exactly executed non-roll design gives them a firmer grip and better balance which results in greater ease and speed for artists. The weight is ideal and durability assured through the skillful molding of the *correct* plastic material. Vivid, distinctive colors make the styli types quickly identifiable, thereby saving the artist's time.

The production of these stylus handles naturally presented their own unique engineering and molding problems. But the end results: better performance, smarter appearance, more sales appeal are typical of all Mills plastic products, created in America's finest, most modern molding plant.

One of our representatives will gladly show you how to make sure your plastic products have these important extra values. Tell us today when he may call.

Mimeograph stylus handles molded for A. B. Dick Company, Chicago

Write on your letterhead for the new Injection Molded and Extruded Plastics Catalog. Or, for detailed information about [illegible]®, piping, tubing and fittings, write for circulars containing data and illustrations. ®Trademark registered

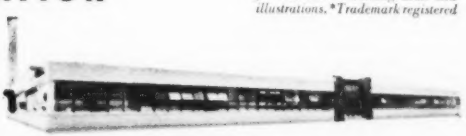
ELMER E. MILLS CORPORATION

INJECTION MOLDERS and EXTRUDERS of: Tenite, Lumarith, Plastacele, Lucite, Nylon, Ethyl Cellulose, Plexiglas, Polystyrene, Styron, Loalin, Vinylite, Geon, Plexene, Polyethylene, Cerex, Forticel, [illegible]®, Saran, and other Thermoplastic Materials.

2930 NORTH ASHLAND AVENUE • CHICAGO 13, ILLINOIS

NEW ADDRESS

NEW PLANT



To Protect Motors From Burning Out ...To Cut Costly Repairs...

USE KLIXON MOTOR PROTECTORS

Users of electric motors can be sure that they won't be troubled with burnouts if they specify and use motors with built-in Klixon Protectors. Not only will you cut motor burnouts, but you will also save money and time by practically eliminating costly repairs and replacements.

Built-in as an inherent part of the motor by the manufacturer, Klixon Protectors follow every temperature change and snap the power "off" should the motor become dangerously overheated. When the motor cools sufficiently they snap the power "on" automatically or by pushing the reset button, depending on the type of protector used. Klixon Protectors provide permanent protection . . . constantly guard the motor over its full operating life. Harmless momentary overloads do not cause nuisance tripouts.

Keep your motors and other equipment, such as transformers, solenoids, adjustable transformers, etc., operating—specify equipment with Klixon Protectors. The additional cost is low . . . pays for itself many times over by preventing burnouts, repairs and replacements.

KLIXON

HERE'S HOW KLIXON PROTECTORS OPERATE:

CLICK . . . IT'S OFF!

When temperature within the equipment reaches danger point, KLIXON Protector snaps the power "OFF" preventing burnouts.

CLICK . . . IT'S ON!

As soon as equipment cools to safe operating temperature, the KLIXON Protector automatically snaps the power "ON" again . . . or by pushing the button on manual reset type.

SPENCER THERMOSTAT

DIVISION OF METALS & CONTROLS CORP.

907 FOREST STREET, ATTLEBORO, MASSACHUSETTS

IN FINE CUTLERY STEELS SHARON HAS THE EDGE

When leading cutlery manufacturers asked for a tough, durable steel that would hold a razor edge indefinitely, be rust and stain proof, abrasion-resistant and attractive, the Sharon Steel Corporation developed Sharon Stainless 440-B with Molybdenum to meet every requirement. It is this leadership that makes Sharon the nation's foremost producer of fine cutlery steels. Other Sharon products for cutlery include Chrome Vanadium, Chrome Moly, Chrome Vanadium Moly, High Carbon Stainless and Special High Carbon Alloys.

SHARON STEEL CORPORATION *Sharon, Pennsylvania*

PRODUCTS OF SHARON STEEL CORPORATION AND SUBSIDIARIES: THE NILES ROLLING MILL COMPANY, NILES, OHIO; DETROIT TUBE AND STEEL DIVISION, DETROIT, MICHIGAN; BRAINARD STEEL COMPANY, WARREN, OHIO; SHARONSTEEL PRODUCTS COMPANY, DETROIT, MICHIGAN, AND FARRELL, PENNA.; CARPENTERTOWN COAL & COKE CO., MT. PLEASANT, PENNA.; FAIRMONT COKE WORKS, FAIRMONT, W. VA.; MORGANTOWN COKE WORKS, MORGANTOWN, W. VA.; JOANNE COAL COMPANY, RACHEL, W. VA. Hot and Cold Rolled Stainless Strip Steel—Alloy Strip Steel—High Carbon Strip Steel—Galvanite Special Coated Products—Cooperage Hoops—Electrical Steel Sheets—Hot Rolled Annealed and Descaled Sheets—Galvanized Sheets—Enameling Grade Steel—Welded Tubing—Galvanized and Fabricated Steel Strip—Steel Strapping, Tools and Accessories.

DISTRICT SALES OFFICES: Chicago, Ill., Cincinnati, O., Cleveland, O., Dayton, O., Detroit, Mich., Indianapolis, Ind., Milwaukee, Wis., New York, N. Y., Philadelphia, Penna., Rochester, N. Y., Los Angeles, Calif., San Francisco, Calif., St. Louis, Mo., Montreal, Que., Toronto, Ont.

INTERNATIONAL HARVESTER

cuts cost 42%

On Refrigerator Application

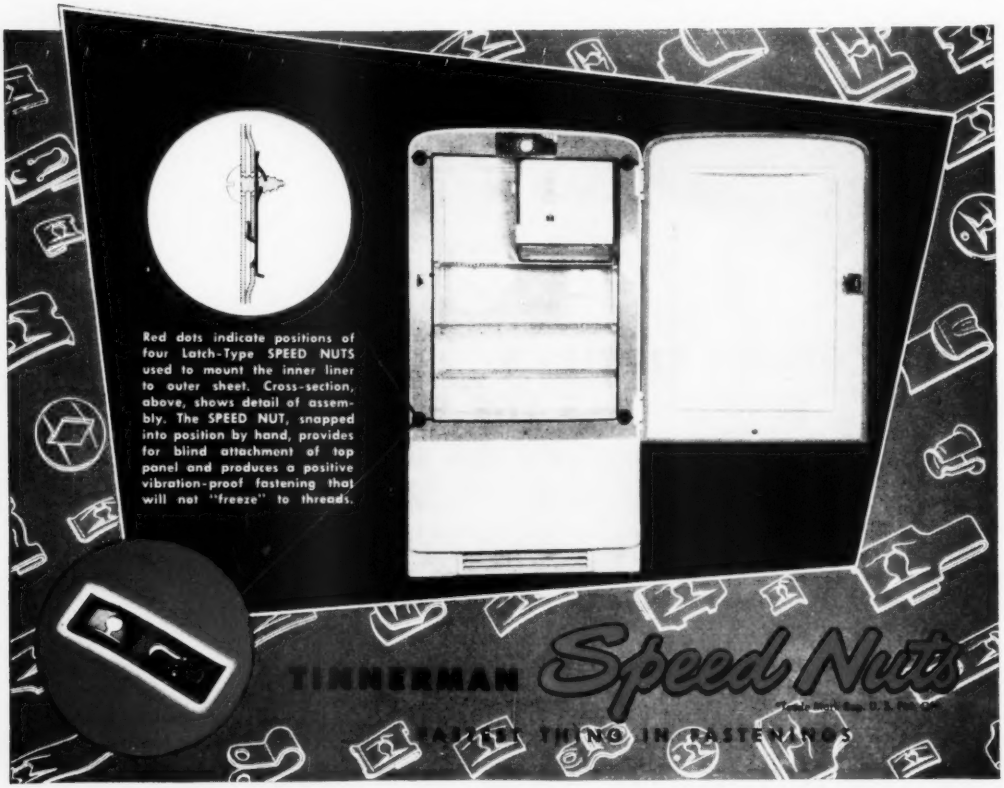
When International Harvester used four Latch-Type SPEED NUTS to replace four projected weld nuts on their new refrigerator, these important benefits were gained:

1. Cost of fasteners was reduced 24% . . .
2. Portable welding equipment was transferred to other jobs . . .
3. *Total assembly savings of 42% was effected!*

Just this *one* of the many SPEED NUT applications on this product created a savings of major proportions.

In your search for ways to reduce *your* costs or improve product quality, why not investigate the Tinnerman SPEED NUT brand of fasteners? The complete line includes more than 4000 shapes and sizes.

Let us conduct a thorough Fastening Analysis of your product. Your Tinnerman representative can supply details. He's listed in major city phone directories. Or write: TINNERMAN PRODUCTS, INC., 2040 Fulton Rd., Cleveland 13, Ohio. In Canada: Dominion Fasteners Limited, Hamilton.


Red dots indicate positions of four Latch-Type SPEED NUTS used to mount the inner liner to outer sheet. Cross-section, above, shows detail of assembly. The SPEED NUT, snapped into position by hand, provides for blind attachment of top panel and produces a positive vibration-proof fastening that will not "freeze" to threads.
TINNERMAN Speed Nuts
HARDEST THING IN FASTENINGS

EX-CELL-O CAN PRODUCE THEM . . .

. . . Parts To Your Specifications In The Exact Volume You Require

Within its extensive organization Ex-Cell-O has exceptionally complete and modern facilities for machining, heat treating, sub-assembly and inspection, in addition to an engineering staff widely experienced and ready to serve you in solving your parts problems. Ex-Cell-O's manufacturing skill represents the most improved methods for producing your parts—from rough stock to finished piece. Ex-Cell-O, with all these facilities under one roof and one responsible management, offers many economical advantages. To get the best in quality and economy in parts, why not send a part print to Ex-Cell-O in Detroit? Write today.

XLO

To learn more about Ex-Cell-O's modern and complete parts production facilities, send for Ex-Cell-O Bulletin No. 36151.

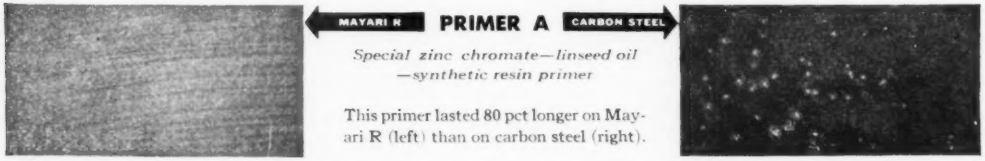
EX-CELL-O CORPORATION DETROIT 32 MICHIGAN

MANUFACTURERS OF PRECISION MACHINE TOOLS • CUTTING TOOLS • RAILROAD PINS AND BUSHINGS
DRILL JIG BUSHINGS • AIRCRAFT AND MISCELLANEOUS PRODUCTION PARTS • DAIRY EQUIPMENT

49-28

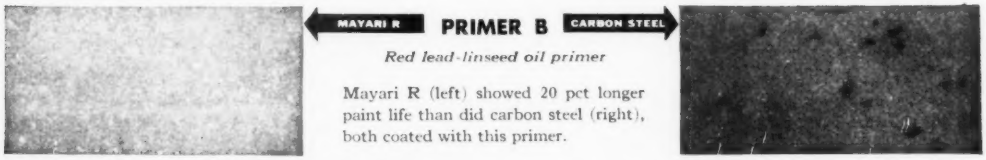
Tests show MAYARI R holds paint 20% to 80% longer

On December 22, 1944 a test was started to determine the relative paint adherence of Mayari R steel and ordinary carbon steel. Five specimens of each of these steels in 4-in. by 4-in. by ¼-in. angle sections with typical partly rusted scale surfaces were wire brushed and given a coating of each of five different types of primer paint at a uniform dry film thickness of 2.5 mils. These painted sections were then placed at a 45-degree angle in a corrosive industrial atmosphere. After exposure under identical conditions for the same period of time, adherence results were as shown below.



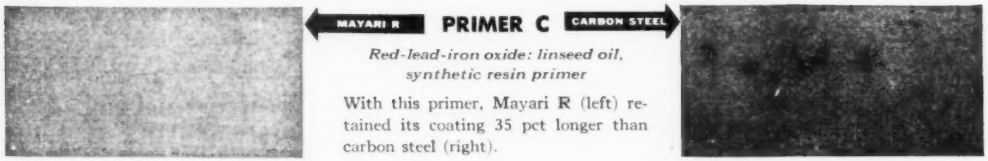
Special zinc chromate—linseed oil —synthetic resin primer

This primer lasted 80 pct longer on Mayari R (left) than on carbon steel (right).



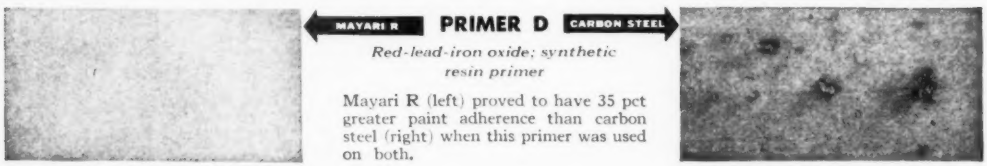
Red lead-linseed oil primer

Mayari R (left) showed 20 pct longer paint life than did carbon steel (right), both coated with this primer.



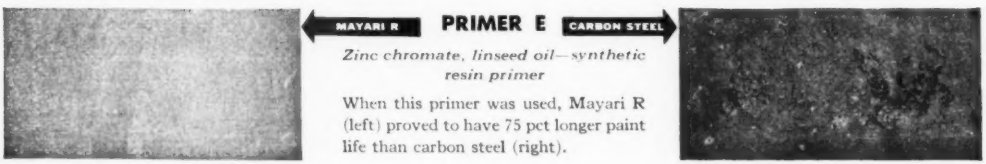
Red-lead-iron oxide: linseed oil, synthetic resin primer

With this primer, Mayari R (left) retained its coating 35 pct longer than carbon steel (right).



Red-lead-iron oxide; synthetic resin primer

Mayari R (left) proved to have 35 pct greater paint adherence than carbon steel (right) when this primer was used on both.



Zinc chromate, linseed oil—synthetic resin primer

When this primer was used, Mayari R (left) proved to have 75 pct longer paint life than carbon steel (right).

This research investigation, confirmed by the experience of Mayari R users in many industrial applications, shows how important savings in paint and labor are made possible through the use of Mayari R low-alloy, high-tensile, corrosion-resisting steel.

BETHLEHEM STEEL

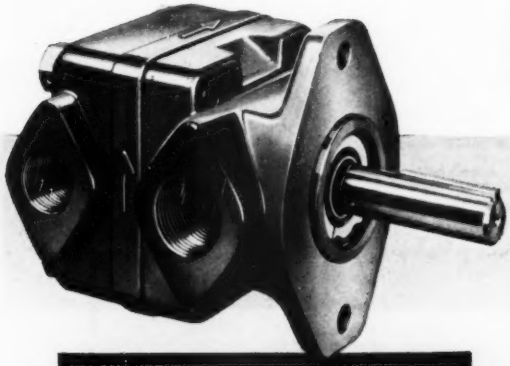
BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation
Export Distributor: Bethlehem Steel Export Corporation

the pump designed SPECIFICALLY FOR mobile equipment service

the NEW series V-200

VICKERS
BALANCED VANE PUMP



THE ONLY PUMP THAT AUTOMATICALLY MAINTAINS CORRECT RADIAL AND LATERAL CLEARANCES AT ALL TIMES

The rigorous job requirements of construction, agricultural, automotive and materials handling machinery have long pointed out the need for a hydraulic pump expressly designed for this service. The new Vickers V-200 Balanced Vane Pump has been designed and developed to meet these requirements with the usual Vickers high quality workmanship . . . all adding up to the "Best Pump Value" for this industry.

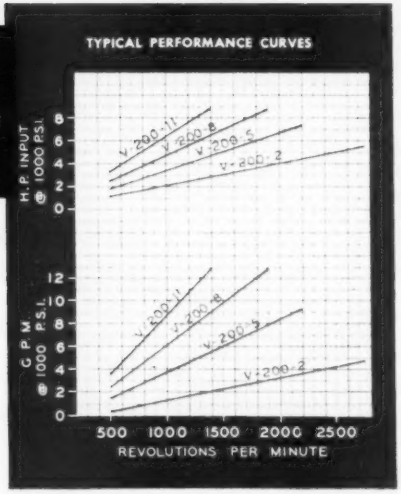
Longer life at maximum efficiency, far in excess of fixed clearance pumps, is assured as the Vickers Pump is the only pump designed to maintain both radial and lateral running clearances at all times. Not only is normal wear perfectly compensated, the pump even automatically adjusts its clearances to oil viscosity variations resulting from temperature change. As a result, correct clearances are maintained and more oil is delivered for useful work.

For many installations the nominal rated capacity of the pump is adequate, making it unnecessary to select the next larger size to provide additional capacity to compensate for loss due to high operating pressures, increased temperatures or normal wear. Thus, in many cases, a smaller pump can be used resulting in a more compact, efficient, and economical installation.

The tried and proven Vickers feature of "hydraulic balance" eliminates bearing loads resulting from pressure. The vane principle provides for no-load starting . . . important in cold weather cranking. Greater mounting adaptability is another advantage.

For better service, much longer life, with maximum efficiency all the way . . . you need Vickers V-200 Pump on your mobile equipment. Write for Bulletin 49-52.

AVAILABLE IN FOUR CAPACITIES WITH THE SAME EXTERIOR DIMENSIONS



Write for **NEW BULLETIN 49-52**

3905

VICKERS
Incorporated
DIVISION OF THE SPERRY CORPORATION
1454 OAKMAN BLVD. DETROIT 32, MICHIGAN

Application Engineering Offices: ATLANTA • CHICAGO CINCINNATI • CLEVELAND • DETROIT • LOS ANGELES • NEWARK PHILADELPHIA • PITTSBURGH • ROCHESTER • ROCKFORD ST. LOUIS • SEATTLE • TULSA • WASHINGTON • WORCESTER

Textile roll with body of Meehanite Metal and cover of bronze, both cast centrifugally by Shenango-Penn to assure exceptional strength and life. Shenango-Penn offers modern machining facilities for completely finished parts (as shown) or any stage of completion desired.

How this textile roll might smooth out a problem for YOU

IF SYMMETRICAL parts (such as sleeves, liners, rings, bushings, rolls and roll covers) figure in the machinery you build or operate, the above roll has qualities that could probably save you time and money.

The roll's body is Meehanite Metal—a big advantage in itself. The cover is bronze. Both are Shenango-Penn *centrifugal* castings. This means fine-grain, *pressure-dense* metal, assuring exceptional strength and hardness, and permitting the finest kind of finish. You just can't beat this combination for resistance to wear, breakage and distortion . . . for *long life!*

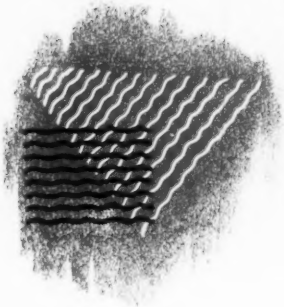
That's why Shenango-Penn is continually producing symmetrical, annular and tubular parts, large and small, for many services in many industries. Send for free bulletins on either ferrous or non-ferrous made-to-order centrifugal castings or on *centrifugally cast* bronze bushing stock in standard sizes.

SHENANGO-PENN

SHENANGO-PENN MOLD COMPANY
678 WEST THIRD STREET • DOVER, OHIO
Executive Offices: Pittsburgh, Pa.

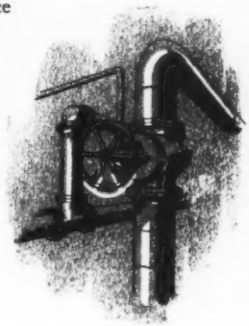
ALL BRONZES • MONEL METAL
NI-RESIST • MEEHANITE METAL®

3 places you can PUT ON THE HEAT with General Electric Calrod* Heaters



PROCESS AIR

For practically any process requiring heated air . . . baking, drying, curing, warming, ripening, softening, etc. . . . there is a suitable Calrod heater . . . fin-Calrod heaters for forced convection with rapid heat transfer; Calrod tubular heaters for high-temperature, low-air-flow operation where space is limited; strip heaters for relatively low temperatures with natural convection.



PIPELINES

G-E heating cable will keep viscous liquids free-flowing and water solutions from freezing during cold weather. For pipelines handling materials which require high temperatures, G-E Calrod tubular heaters are a "natural."

SOFT METALS

For standard tinning, babbitting, lead molding and soldering pots, *put the heat right where it is wanted* . . . in the metal for maximum heating efficiency and cooler working conditions with G-E Calrod cast-in "over-the-side" and "through-the-side" immersion heaters . . . in a wide variety of shapes and sizes.

*Reg. U. S. Pat. Off.

BEFORE you design your equipment or machinery . . . before you convert existing installations . . . be sure to consult a G-E Industrial Heating Specialist. His recommendations may pay you real dividends in terms of more efficient heating and better designs.

And be sure to see the latest slide film in the *MORE POWER TO AMERICA* series, "Heat—Where You Want It." It will show you exactly where and how you can build-in electric heat for better products and better designs.

YOU CAN PUT YOUR CONFIDENCE IN

GENERAL ELECTRIC

Apparatus Dept., Sec. A720-7, General Electric Co., Schenectady 5, N. Y.

Send me the following idea-packed application bulletins:

- ☐ GEA-5095 Heating Pipelines
- ☐ GEA-5096 Heating Process Air
- ☐ GEA-5098 Melting Soft Metals
- ☐ I'd like to see the new slide film, "Heat—Where You Want It."

Name .....

Company .....

Address ..... State .....

City .....

720-7

Michigan WELDED STEEL TUBING

The Modern Electric Resistance Welded Steel Tubing

Can be Bent

FLANGED, EXPANDED, TAPERED, DEPRESS BEADED, EXPAND BEADED, ROLLED, EXTERNAL UPSET, INTERNAL UPSET, SPUN CLOSED, FORGED, BEVEL FLANGED, FLATTENED, SWAGED, FLUTED

A SLIDE
AND
A RIDE
Michigan Welded Steel Tubing is used in products that bring joy to children and comfortable and convenient transportation for all.

ROUND

¼" to 4" O. D. 9 to 22 gauge

SQUARE-RECTANGULAR

½" to 2" 20 gauge 1" to 2¾", 14, 16, 18 gauge

PRODUCTS for thousands of everyday uses are made better and more economically with Michigan Electric Resistance Welded Steel Tubing. The reasons? Uniform strength, weight, ductility, ID and OD, machinability and weldability. Examine these and many other advantages of using Michigan tubing in the manufacture of your product.

THE OLDEST NAME IN ELECTRIC RESISTANCE WELDED STEEL TUBING

Michigan STEEL TUBE PRODUCTS CO.

33 Years in the Business

9450 BUFFALO STREET • DETROIT 12, MICHIGAN

FACTORIES: DETROIT, MICHIGAN • SHELBY, OHIO

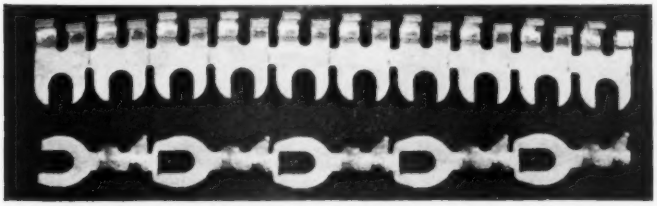
For Engineering advice and technical help in the selection of tubing best suited to your needs consult us.

DISTRIBUTORS: Steel Sales Corp., Detroit, Chicago, St. Louis, Milwaukee, Indianapolis and Minneapolis—Miller Steel Co., Inc., Hillside, N. J.—C. L. Hyland, Dayton, Ohio—Dirks & Company, Portland, Oregon—James J. Shannon, Milton, Mass.—Service Steel Co., Los Angeles, Calif.—American Tubular & Steel Products Co., Pittsburgh, Pa.—Strong, Carlisle & Hammond Co., Cleveland, Ohio—Drummond, McCall & Co., Ltd., Toronto, Canada.

COPPER ALLOY BULLETIN

REPORTING NEWS AND TECHNICAL DEVELOPMENTS OF COPPER AND COPPER-BASE ALLOYS

Prepared Each Month by BRIDGEPORT BRASS COMPANY "Bridgeport" Headquarters for BRASS, BRONZE and COPPER



Self-soldering tandem terminals are attached by machine which contains heating unit. Courtesy Patton-MacGuyer Co., Providence, R. I.

Cutting Costs by Mechanizing Slow Hand Operations

Elimination of expensive hand operations is one of the important ways open to fabricators for substantially cutting costs.

This is always a challenge to the ingenuity of machine and product designers to develop methods for changing old-time hand operations to semi or completely automatic cycles. This may involve both the development of a special-purpose machine and the redesign of the product itself.

Cutting High-Cost Soldering

The method for soldering copper terminals to insulated wires is an example of such cost-cutting. Originally the terminals were handled individually and required fluxing, tinning, bending and soldering with either an open flame or soldering iron.

The mechanization of this job involved the development of a machine to do the job automatically, with the exception of inserting the wires. It also required redesigning the terminals in strip form.

Progressive dies were made to blank, pierce and bend the terminals but not clip them off. This permitted tinning and depositing the solder on a mass production basis. The fact that the terminals remain joined until fed into the machine does away with the troublesome problem of hand feeding individual terminals which tend to tangle up.

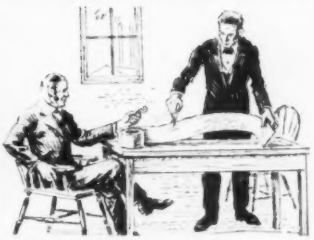
The machine feeds the roll of tandem terminals into a die. When the wire is inserted and the lever tripped, the die closes, cutting off a single terminal, bending the locking lugs around the wire and simultaneously applying heat to melt the solder. Instead of a few hundred by hand, the machine is capable of producing 1200 or more assemblies per hour.

Copper-Base Alloys Can Help Cut Fabricating Costs

Copper, with its high electrical conductivity, is eminently suited for this job. It can be blanked, formed and clipped with minimum power.

It is extremely ductile which permits the cold bending of locking lugs around the wire without breaking. Copper's high heat conductivity makes it possible to heat the terminal speedily, and dissipate the heat rapidly when the current is shut off.

Product designers interested in cutting production costs will appreciate the fine workability and versatility of the copper-base alloys. Much valuable information on the characteristics of copper, brass, tin, bronze, silicon bronze and aluminum bronze can be gleaned from Bridgeport's Technical Handbook. Contact our nearest Bridgeport sales office for technical help on your metal problems.



Did You Know...

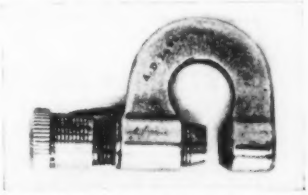
Bridgeport Brass Developed First Mike?

It was 1867, two years after Bridgeport Brass was founded. The Union Metallic Cartridge Company (now Remington Arms) had returned a quantity of brass because it was "out of gauge".

S. R. Wilmot, superintendent, applied his "finger" gauge on several rolls and stoutly denied the charge. However, the customer's gauge did not agree with Mr. Wilmot's, or with a third.

Mr. Wilmot then took matters into his own hands and called in Mr. Laws, of the Mechanical Department. He demanded a gauge with a calibrated moving part that would measure thicknesses accurately.

Meeting emergencies was nothing new to Bridgeport Brass and soon the first "mike" was born. Mr. Laws made five more to fulfill requests from most important customers, but when more were called for, he rebelled. The firm of Joseph R. Brown and Lucian Sharpe was asked to take this task off his hands.



Granddaddy of the micrometer caliper—designed and made by Bridgeport Brass in 1867.

With some minor modifications in the method of reading, the micrometer caliper of today is essentially the same as the one which Bridgeport developed for its own use in 1867.

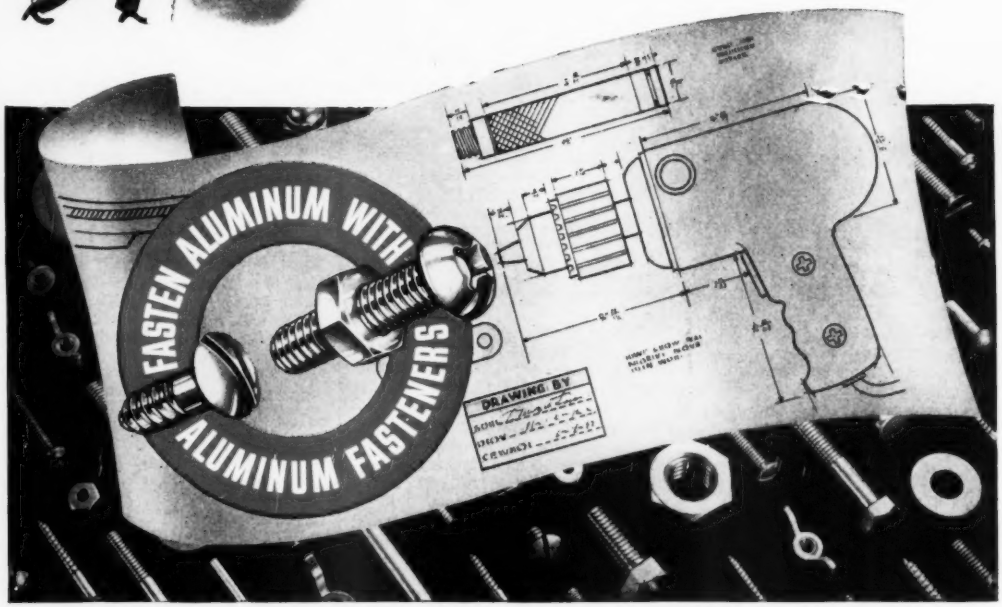
Industry is indebted to Bridgeport Brass for this universal instrument of precision.

BRASS • BRONZE • COPPER • DURONZE — STRIP • ROD • WIRE • TUBING

MILLS IN
BRIDGEPORT, CONNECTICUT
INDIANAPOLIS, INDIANA
In Canada:
Noranda Copper and Brass Limited, Montreal

BRIDGEPORT BRASS COMPANY
BRIDGEPORT 2, CONNECTICUT
Established 1865
"Bridgeport" *District Offices and Warehouses in Principal Cities*

AVOID "JOINT TROUBLE" IN ALUMINUM ASSEMBLIES



SPECIFY ALCOA ALUMINUM FASTENERS

right on your drawings!

WRITE FOR FREE SAMPLES

of the types that interest you. And phone your nearest Alcoa sales office or Alcoa distributor for prompt service. ALUMINUM COMPANY OF AMERICA, 618G Gulf Building, Pittsburgh 19, Pa.

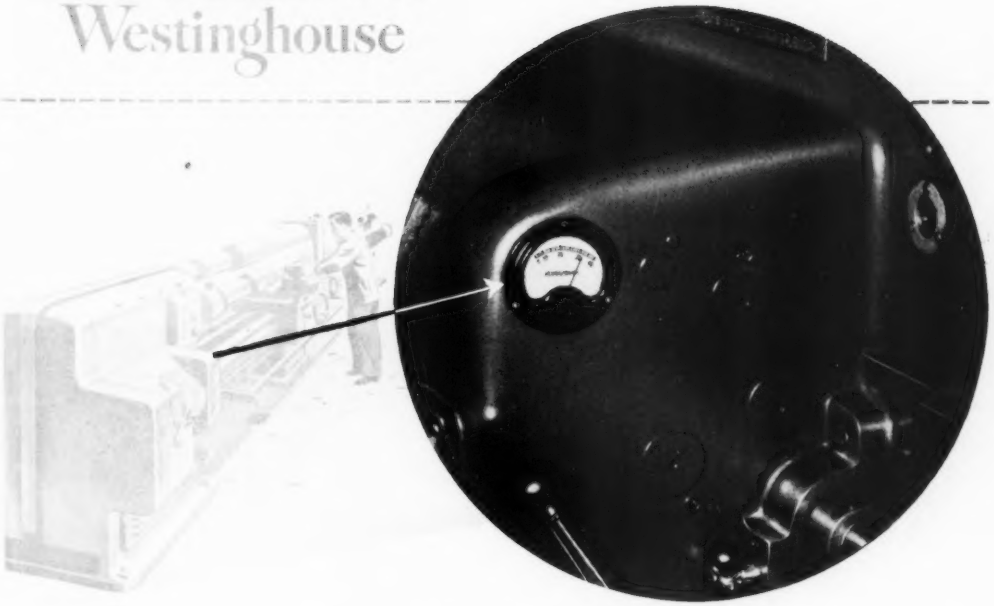
There's no need to run the risk of the galvanic corrosion that can come when aluminum is fastened with dissimilar metals. The complete line of Alcoa Aluminum Fasteners includes all the types required to meet any production assembly need.

Complete ranges of sizes and head types. Slotted or Phillips head. Made to Alcoa quality standards, yet not expensive.

ALCOA *Aluminum* FASTENERS

INGOT • SHEET & PLATE • SHAPES, ROLLED & EXTRUDED • WIRE • ROD • BAR • TUBING • PIPE • SAND, DIE & PERMANENT MOLD CASTINGS • FORGINGS • IMPACT EXTRUSIONS
ELECTRICAL CONDUCTORS • SCREW MACHINE PRODUCTS • FABRICATED PRODUCTS • FASTENERS • FOIL • ALUMINUM PIGMENTS • MAGNESIUM PRODUCTS

YOU CAN BE SURE.. IF IT'S
Westinghouse



This Westinghouse Instrument helps set *New Production Records*

Savings in machine time up to 75% are common among the users of the American Tool Works Company's new hydraulic duplicating lathes!

A standard feature of these lathes is the Westinghouse horsepower instrument. It shows, at a glance, the horsepower being consumed by the cut. This enables the operator to take full advantage of the capabilities of the machine and to make maximum cuts without overloading. Machines can be easily operated at peak loads, without the dangers of overtaxed motors and damaged cutting tools.

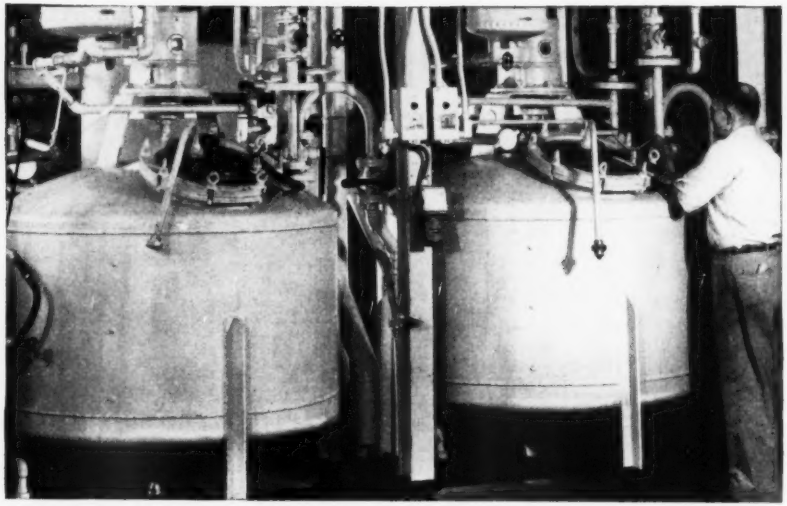
This is another example of the application of Westinghouse instruments to *specific* problems. Westinghouse instruments are *engineered* and built to give you reliable performance in *every* application. The completeness of the line means electrical measuring instruments to fill *your* needs exactly in every field of industry.

Westinghouse instrument specialists are available in the field for consultation. Call your nearest Westinghouse office or write Westinghouse Electric Corporation, P. O. Box 868, Pittsburgh 30, Pennsylvania. J-40373

Westinghouse
ELECTRICAL
MEASURING INSTRUMENTS
FOR *ANY* JOB

For nearly 14 years, the *ingredients* of

. . . have been protected by Nickel-Clad Steel



In operation since 1935, the two bottom tanks of this caustic mixing equipment at Bristol-Myers Company, Hillside, N. J., are Lukens Nickel-Clad Steel; fabricated by Theodore Walter Copper Works of Newark, New Jersey.

There's no metallic contamination of these shaving soap ingredients because they're processed in nickel—no catalytic action to cause off-color by-products. That's why nickel was specified from top to bottom of this mixing equipment. It protects the products and assures long equipment life. After nearly 14 years of use, the tanks are still on the job continually.

Since the bottom tanks work under pressures up to 20 psi, thicker sections were required. By employing Lukens Nickel-Clad Steel, the fabricator obtained adequate thickness—a 20% cladding of nickel permanently bonded to a steel backing plate giving the protection of *solid* nickel at the lower cost of *clad* steel plate.

Do your processes call for nickel, stainless steel, Inconel or Monel? You can get their protection with Lukens Nickel-Clad, Stainless-Clad, Inconel-Clad and Monel-Clad Steels; plates as wide as 178 inches or to over 3 inches thick. Claddings 10% or 20% of total plate thickness suit most needs. The extra-smooth sodium hydride finish makes equipment extra easy to keep clean.

Bulletin 338 and 449 give you additional data on clad steels. For a copy, write Lukens Steel Company, 405 Lukens Building, Coatesville, Pennsylvania.

CLAD METAL STEEL

LUKENS

Nickel-Clad Stainless-Clad
Inconel-Clad Monel-Clad
STEELS

SOLID METAL ADVANTAGES WITH CLAD STEEL ECONOMY

If it's a question of simplifying parts production AND lowering costs, it's just possible the job can be done better and more economically with Van Huffel continuous rolled metal shapes and tubing.

what's YOUR *problem*

Whatever your problem—that new product or troublesome production on your present product—Van Huffel's "under one roof" procedure —designing forming rolls *plus* rolling shapes and tubing— is worth your consideration.

Write for illustrated brochure showing the wide range and diversified application of Van Huffel Shapes and Tubing.

VAN HUFFEL

TUBE CORPORATION · WARREN, OHIO

continuous rolled

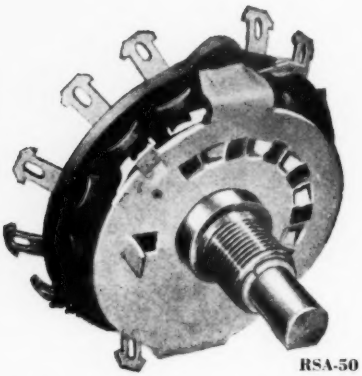
metal

SHAPES

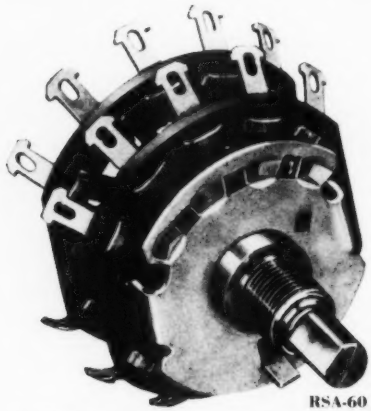
WELDED · LOCK SEAM · OPEN SEAM · BUTTED

TUBING

Two Single or Double Section Switches...



RSA-50



RSA-60

...of Space Saving Design and Mallory Precision Quality

Where space is a factor—dependability essential—the Mallory RSA-50 and RSA-60 switches fill the bill!

These circuit selector switches, with section and terminal design identical to that of the famous Mallory RS-50 and RS-60 switches, are designed for band and tone control switching in radio receivers and other electronic applications where medium and low torque indexing action is desired.

The index assembly is of durable design and constructed with a minimum of parts—affording dependable service life with low torque and positive indexing action.

Note these many features, inherent in all the Mallory RS series, which contribute to their dependability and quality:

- **Insulation of high-grade, low-loss laminated phenolic.**
- **Terminals and contacts of special Mallory spring alloy, heavily silver-plated to insure long life at low contact resistance.**
- **Terminals held securely by exclusive Mallory two-point fastening—heavy staples prevent loosening or twisting.**
- **Double wiping action on contacts with an inherent flexing feature—insures good electrical contact with the rotor shoes throughout rotation.**
- **Six rotor supports on the stator—insure accurate alignment.**
- **Brass rotor shoes, heavily silver-plated—insure low contact resistance.**
- **All shoes held flat and securely to phenolic rotor by rivets—prevents stubbing—insures smooth rotation—*minimum of noise in critical circuits.***

The RSA-50 and RSA-60 are both available in one or two section construction. The RSA-50 accommodates up to twelve terminals on either side of the section and provides from 2 to 6 positions. The RSA-60 accommodates up to ten terminals on either side of the section and provides from 2 to 5 positions. The RSA-60 has the narrow section design—ideal for under chassis mounting, where space saving is paramount.

ENGINEERING DATA SHEET

Send for the Mallory Engineering Data Sheet on the RSA-50 and RSA-60. It contains complete specifications for available circuit combinations with respective terminal locations, dimensional drawings—everything the engineer needs to adapt the RSA-50 or RSA-60 switch to a particular circuit.

SPECIFICATION SHEETS

Specification sheets for the RSA-50 and RSA-60 switches have also been prepared. These sheets are printed on thin paper to permit blueprinting. The sectional drawings indicate standard and optional dimensions—make it easy for you to order production samples built to your requirements.

Precision Electronic Parts—Switches, Controls, Resistors

P. R. MALLORY & CO. Inc.

MALLORY

P. R. MALLORY & CO., Inc., INDIANAPOLIS 6, INDIANA

SERVING INDUSTRY WITH

Capacitors — Rectifiers
Contacts — Switches
Controls — Vibrators
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Resistance Welding Materials

EATON PERMANENT MOLD GRAY IRON CASTINGS *for Hydraulic Applications*

NEW BOOKLET. Send for your copy of the new, illustrated booklet, "The Eaton Permanent Mold Process," which describes the Eaton Permanent Mold machine, and the Permanent Mold Process. It also includes pointers on designing Gray Iron Castings to be produced by the Eaton Permanent Mold Process.

THE dense, non-porous structure of Eaton Permanent Mold Gray Iron Castings insures freedom from leakage under pressure. In addition, this material machines to the high mirror-like finish required on a majority of parts for hydraulic applications. Proper annealing insures that castings will hold size and not distort after machining. Free machinability makes for production speed and holds machining cost to a minimum.

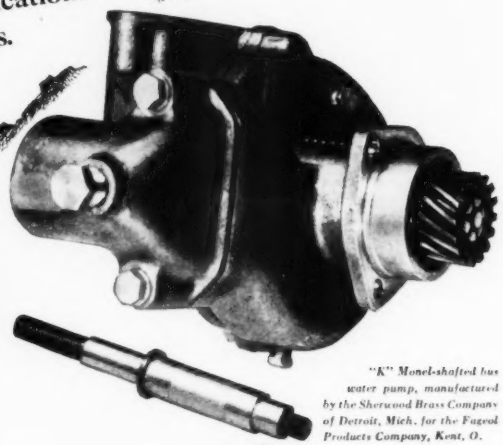
Eaton Foundry Division engineers will be glad to discuss the application of Eaton Permanent Mold Gray Iron Castings to your product.

THE EATON PERMANENT MOLD MACHINE IS A SYMBOL OF THE QUALITY OF GRAY IRON CASTINGS PRODUCED BY THE PERMANENT MOLD PROCESS.

EATON
MANUFACTURING COMPANY
FOUNDRY DIVISION
9771 French Road • Detroit 13, Michigan

WANTED: *A better metal for water pump shafts.*
Working conditions bad...no vacations...
hard physical labor...long hours.

THE TWIN COACH COMPANY
KENT, OHIO



"K" Monel-shafted bus water pump, manufactured by the Sherwood Brass Company of Detroit, Mich. for the Fageol Products Company, Kent, O.

Position Filled by "K" Monel*

Yes...it's a tough job, being a bus water pump shaft. Most metals don't last long at it, as any maintenance man will testify.

That was the situation at the Twin Coach Company. Water pump shafts in their buses were failing with monotonous and costly regularity. Then one day they asked the Fageol Products Company—if something couldn't be done about it.

Something could. The Fageol Products Company came through handsomely. Twin Coach's pumps are now equipped with "K"* Monel shafts...and things are looking *up* in the maintenance department.

Mr. A. G. Hilf, Vice President in charge of production at the Fageol Products Company explains it this way:

"'K' Monel was chosen for water pump shafts because:

1. ***It is corrosion resistant.***
2. ***It can be heat-treated to secure satisfactory hardness.***
3. ***It expands only slightly during extreme variations in water temperatures.***
4. ***It has high resistance to corrosive mineral salt deposits encountered in some localities.***

"This combination of desirable characteristics should result in greatly increased service life and much reduced maintenance in 'K' Monel-shafted pumps."

Because of its unusual properties, "K" Monel has an excellent service record in a wide range of industrial "task" applications. In fully age-hardened condition, "K" Monel has a minimum yield strength of 100,000 psi, and a tensile strength of over 140,000 psi. Cold-drawn, age-hardened "K" Monel has a Brinell (3000 kg) hardness of 265—320. In addition, this alloy is rustproof and resistant to most commonly-encountered corrosives. And of particular importance in vehicular applications, "K" Monel offers high resistance to fatigue failure.

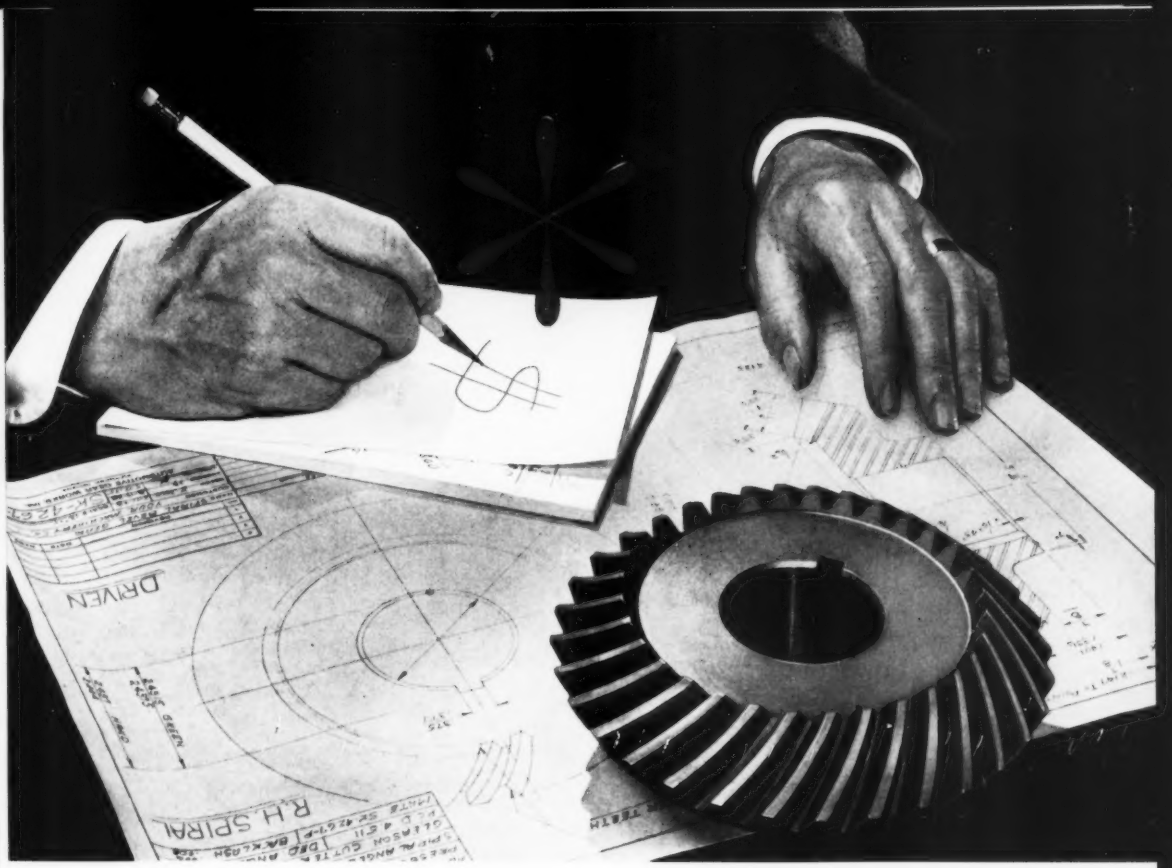
For further information, ask for Bulletin T-9, *Engineering Properties of "K" Monel*. Remember, too, that our Technical Service Department is always ready to help with your specific metal-selection and fabrication problems.

THE INTERNATIONAL NICKEL COMPANY, INC.
67 Wall Street, New York 5, N. Y.
*Reg. U. S. Pat. Off.

*Monel**

...FOR MINIMUM MAINTENANCE

EMBLEM OF SERVICE
INCO
TRADE MARK



* What do you mean—"*How much?*"

You're buying gears. You naturally want to know "*How much?*"

How much what?

How much they will cost per unit on delivery? That's *one* important consideration, but not the only one by any means.

How much will they save on installed cost?

How much will they add to the saleability, performance, and endurance of your product?

How much (or how little) will they crowd tolerance limits?

How much will they relieve you of service headaches and expenses?

How much will they reflect the experience, integrity, and skill of their makers?

And how much will the manufacturer respect your delivery requirements?

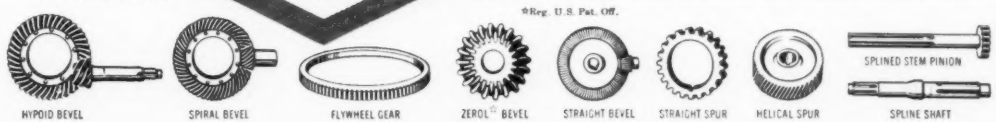
When your "*How much?*" means all this—and not just first price alone—you're talking "Double Diamond" language. You're speaking of long-term value and long-term thrift, of lowest final cost. You're buying gears on the basis that has steadily built "Double Diamond" volume and reputation through almost thirty-five years of gear-making.

DOUBLE DIAMOND
TRADE MARK
GEARS

Made by
Automotive Gear Works, Inc.
RICHMOND, INDIANA

• • • • • • FOR AUTOMOTIVE FARM EQUIPMENT AND GENERAL INDUSTRIAL APPLICATIONS • • • • •

*Reg. U.S. Pat. Off.

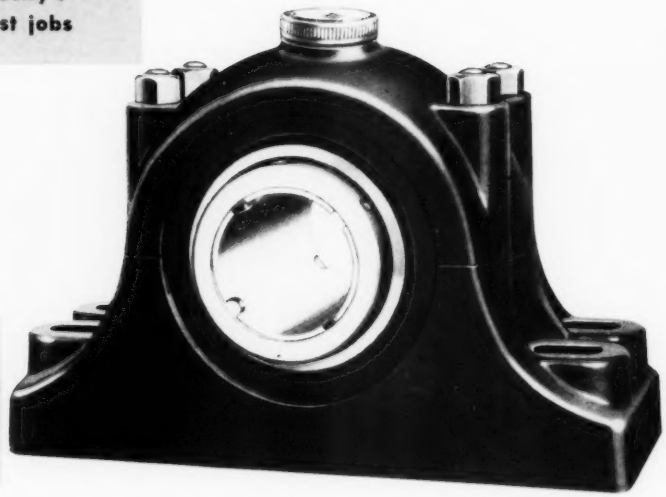


HYPOID BEVEL · SPIRAL BEVEL · FLYWHEEL GEAR · ZEROL* BEVEL · STRAIGHT BEVEL · STRAIGHT SPUR · HELICAL SPUR · SPLINE SHAFT

Quality-proved by use on millions of industry's toughest jobs

Mounted, sealed, housed, fully assembled, ready to lock on the shaft

Delivered from stock in 4 basic types and a vast range of sizes



"DODGE-TIMKEN" MEANS QUALITY!

OTHER DODGE "FIRSTS"

TAPER-LOCK SHEAVES
Easy on — easy off — holds fast to the shaft.

ROLLING GRIP CLUTCH
No toggles! Great flexibility — positive drive.

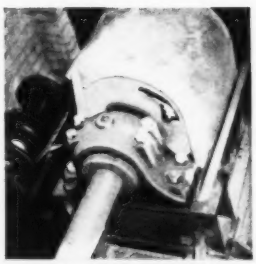
"SC" BALL BEARING
Pillow Block with new Neoprene metallic-backed seal.

It was Dodge who took the famous Timken Bearing, mounted it, sealed it, housed it and delivered a pillow block of new high quality—fully assembled, ready to lock on the shaft and carry the power loads of industry with new efficiency.

Power savings, improved machine operation, reduced maintenance, elimination of spoilage and steadier production—all result so regularly from the application of Dodge-Timken Bearings that this great line is widely accepted as the standard for comparison in up-to-date power transmission layouts.

Ask the Transmissioneer, your local Dodge Distributor, how these bearings and other Dodge "firsts" can help you achieve better, more economical production.

DODGE MANUFACTURING CORPORATION, MISHAWAKA, IND.



100-TON PULL

Three Dodge-Timken Pillow Blocks carry the load of a 100-ton pull of castings in and out of a shot blast chamber for the Falk Corporation, at Milwaukee. The bearings save the gear reducer from side pull and allow the shaft to turn easily even while taking the full load. Perfect operation for 8 years to date.

DODGE

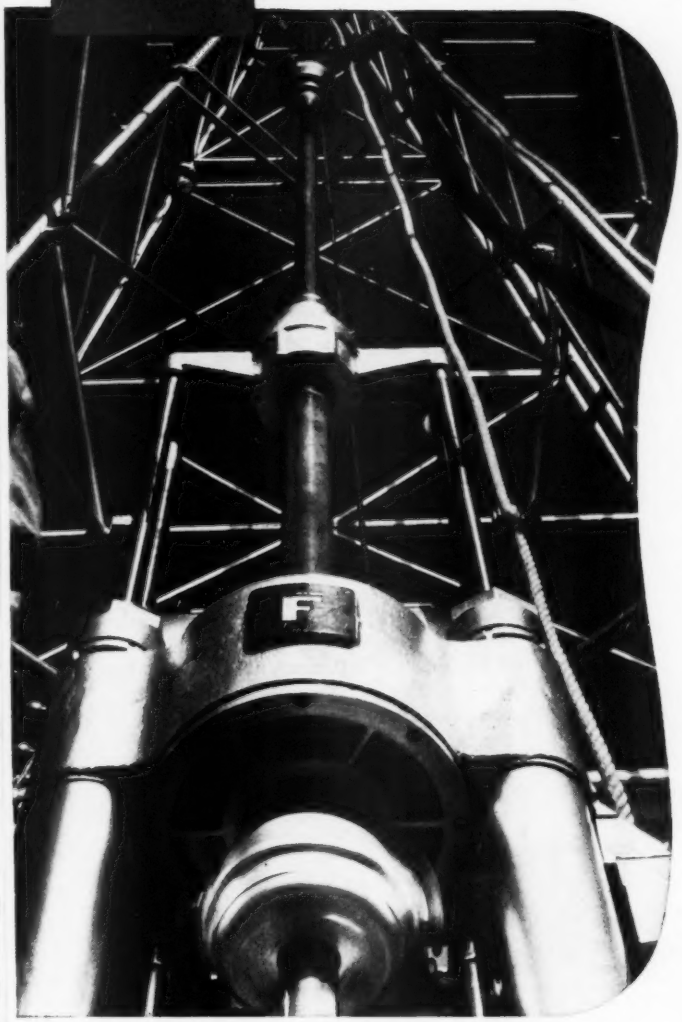
of Mishawaka, Ind.

CALL THE TRANSMISSIONEER. Look for the name of the Transmissioneer, your local Dodge distributor, under "Power Transmission Equipment" in your classified telephone directory.

NAME PLATES

FOR YOUR NAME PLATE REQUIREMENTS, WRITE OUR SUBSIDIARY, ETCHING COMPANY OF AMERICA, 1520 MONTANA STREET, CHICAGO 14, ILLINOIS

NOW... another example of the excellence of SHELBY SEAMLESS TUBING for mechanical and structural applications



WHEN a large southwest supply company* surveyed the field of possible materials with which to build its new portable drilling rig, the prime requisite in its design and structure was *maximum strength with minimum weight.* This naturally led to the choice of SHELBY Seamless Steel Tubing.

Not only is the entire structure of the rig mast fabricated from SHELBY Seamless Mechanical Tubing, but the hydraulic cylinders which raise and lower the mast, as well as the Kelly are also 100% SHELBY Tubing.

This is but one instance in which a user has been able to do a complete job—and make a better product—with SHELBY Seamless Mechanical Tubing. There are innumerable other cases . . . all proving the superiority of tubular seamless steel for an infinite variety of machinery and equipment parts and structural applications.

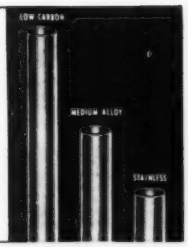
Made by NATIONAL Tube Company—the world's largest manufacturer of steel tubular products—SHELBY Seamless is obtainable, in addition to round, in square, rectangular, and other special shapes . . . in any commercial size from ⅜ to 10½ inches OD, and in wall thicknesses from .035 inch to 1.500 inch cold drawn . . . and in a wide range of steel grades and anneals. Our engineers will be glad to make recommendations based on your particular requirements.

Name upon request

NATIONAL TUBE COMPANY
PITTSBURGH, PA.
(TUBING SPECIALTIES DIVISION)
COLUMBIA STEEL COMPANY, SAN FRANCISCO
PACIFIC COAST DISTRIBUTORS
UNITED STATES STEEL EXPORT COMPANY
NEW YORK

SHORT CUT TO FASTER LOWER-COST PRODUCTION

SHELBY Seamless Steel Tubing comes to you ready for immediate fabrication or machining. Thus, by being able to start with preshaped stock instead of with cumbersome solid castings or forgings, you eliminate or greatly reduce many time- and labor-consuming operations, as well as the costly waste of material.

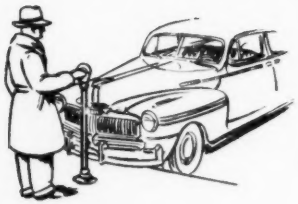


SHELBY SEAMLESS STEEL TUBING

UNITED STATES STEEL

MADISON-KIPP

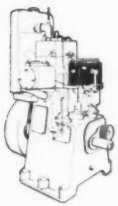
DIE CASTINGS



The Kipp die casting process often offers cost economies, combined with strength, permanence, lightness and eye appeal in the production of metal parts. Please send your inquiries to our home office in Madison, Wisconsin.

MADISON-KIPP

LUBRICATORS



Fresh oil by the measured drop, from a Madison-Kipp Lubricator, is the most dependable method of lubrication ever developed. It is applied as original equipment on America's finest machine tools, work engines and compressors.

MADISON-KIPP

KIPP *Air* TOOLS

Kipp Air Grinders give you spectacular off hand grinding. Their high, sustained speeds . . . actually **grind** . . . not just **rub.** They get into small places with small wheels. Every toolmaker needs one. There are 3 models: Model JA—50,000 R.P.M. for wheels up to ⅞" diameter; Model TT—30,000 R.P.M. for wheels up to 1¼" diameter; Model PVT—10,000 R.P.M. for wheels up to 2½" diameter. Send for the complete Air Tool Catalog.

MADISON-KIPP CORPORATION

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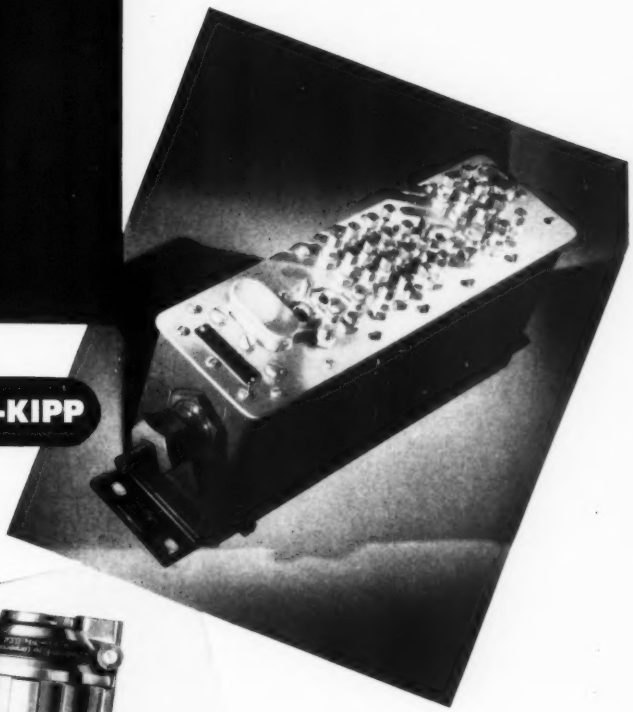
ANCIENS ATELIERS GASQUY, 31 Rue du Marais, Brussels, Belgium, sole agents for Belgium, Holland, France, and Switzerland.

WM. COULTHARD & CO. Ltd., Carlisle, England, sole agents for England, most European countries, India, Australia, and New Zealand.

- *Skilled in* DIE CASTING *Mechanics*
- *Experienced in* LUBRICATION *Engineering*
- *Originators of Really High Speed* AIR TOOLS

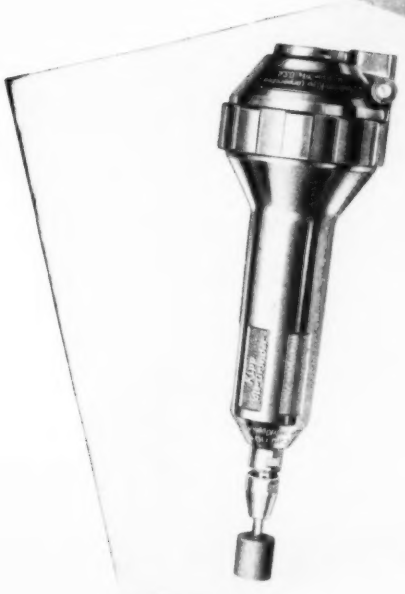
MADISON-KIPP

Aluminum
DIE CASTINGS



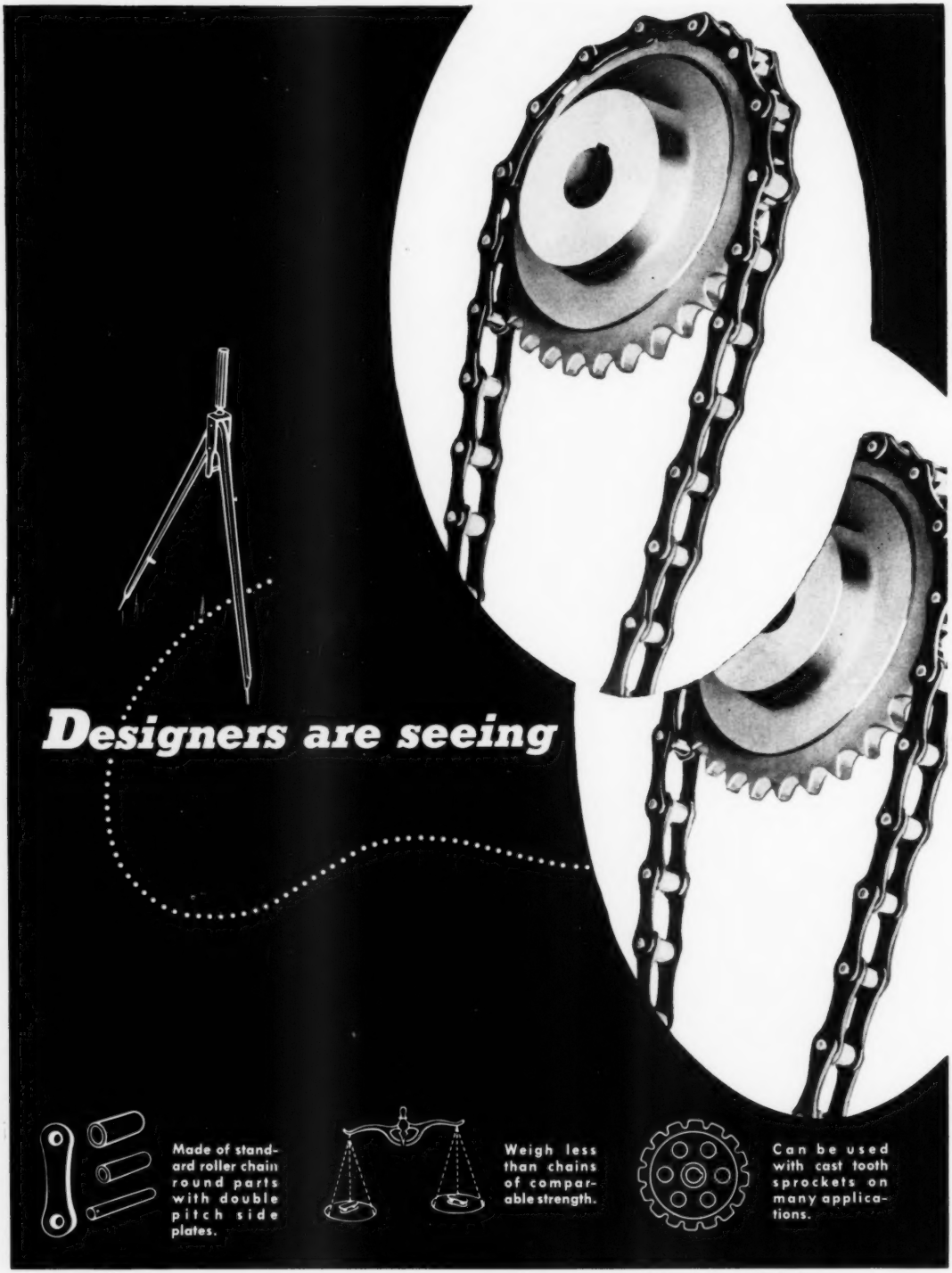
MADISON-KIPP

Fresh Oil
LUBRICATORS



MADISON-KIPP

KIPP *Air* TOOLS


Designers are seeing
Made of standard roller chain round parts with double pitch side plates.
Weigh less than chains of comparable strength.
Can be used with cast tooth sprockets on many applications.

for lower costs, lighter weight

DOUBLE

More and more, cost-conscious designers are seeing the advantages of *double pitch* roller chain. For drive or conveyor service, where speeds range from slow to medium . . . loads light to moderate, double pitch chain offers you these important design advantages:

1. CUTS COST. Double pitch roller chain is lower in cost. In many applications, it can be used with cast instead of cut-tooth sprockets for even greater cost reductions.

2. SAVES WEIGHT. For a given strength, double pitch chain is lighter than other type chains.

3. LONG-LIFE EFFICIENCY. Double pitch chain uses standard long-lasting roller chain round parts with side plates of the same material as standard roller chains but double in pitch.

4. UNIFORM WEAR. Correctly applied, parallel strands of double pitch roller chains will wear evenly . . . an important advantage for conveying work.

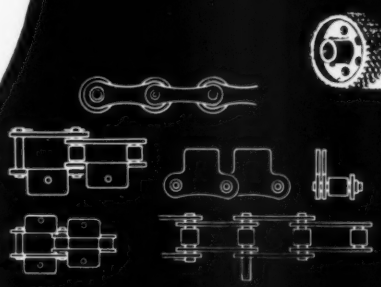
5. SAVES SPACE. Double pitch roller chain takes up less space . . . permits more compact design.

6. VERSATILITY. Double pitch roller chain operates efficiently on long or short centers.

7. OVERSIZE ROLLERS. For efficient, smooth conveyor service, double pitch chain can be furnished with oversize rollers.

Here's a chain that is built to the same exacting standards as standard roller chain . . . that gives you the same basic roller chain features . . . positive power transmission . . . shock-absorbing abilities . . . the ability to drive multiple shafts from a single power source . . . plus its own cost-cutting, weight-reducing advantages.

For all the facts, write Baldwin-Duckworth Division of Chain Belt Company, 321 Plainfield Street, Springfield 2, Massachusetts.



Have a full line of standard attachment links and can be furnished with oversize rollers for efficient, smooth conveyor service.

BALDWIN·REX

ROLLER CHAINS

A complete line from ¼-inch to 2½-inch pitch
Baldwin-Duckworth Division of Chain Belt Company

HOLTZER CABOT

1/30th HORSEPOWER PRECISION MOTORS

Synchronous or induction, split phase or permanent split capacitor, sleeve bearings or ball bearings, with or without gear heads, and in a variety of speeds. Yes, a lot of extra thought went into engineering our broad line of Type R-37 motors. They are built in sizes up to 1/30th horsepower and were created especially for those applications requiring power units between our smaller instrument type motors and our larger commercial types. Specifically they are for devices such as Timers, Electric Typewriters, Recording Instruments, Controllers, Teleprinters, Professional Motion Picture Equipment and Disc, Tape, Wire and Facsimile Recording Devices, Servo Mechanisms, Fans and Blowers. The complete story is told in a new piece of literature. Write or phone today. Ask about the Holtzer-Cabot Type R-37 motors.

Builders of Electric Motors for Three-Quarters of a Century

HOLTZER-CABOT, INC., BOSTON 19, MASS.

OFFICES IN NEW YORK, PHILADELPHIA and CHICAGO

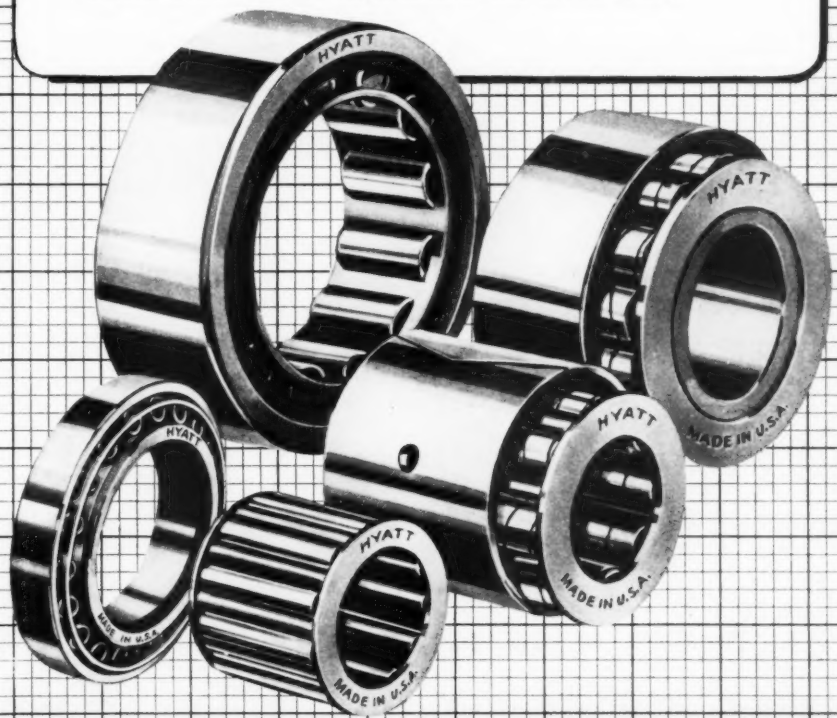
AFFILIATED WITH REDMOND COMPANY, INC.

The Line to Look to... HYATTS

Design engineers, for more than half a century, have learned to look to Hyatt for that better grade of roller bearings which adds to the operating efficiency of machines and equipment in almost every field.

We are probably making just the type, size and width Hyatt Roller Bearing you need for that new job you are designing—or for modernizing your present product.

To help you locate the right roller bearing to fit your job precisely we will gladly send you catalogs or if you wish to consult a member of the Hyatt Engineering Service staff—just write to Hyatt Bearings Division, General Motors Corporation, Harrison, New Jersey.



HYATT ROLLER BEARINGS

WHEN TO USE SELF-ALIGNING DOUBLE ROW RADIAL BALL BEARINGS

Wherever shafts bend or deflect beyond the norm—where it is impossible to machine the housings in line, or when housings are mounted on separate structures and perfect alignment is impossible—Federal Self-Aligning Double Row Radial Ball Bearings meet the need for correcting such misalignment.

These versatile bearings are engineered so that the balls, spacer and inner ring always rotate *freely* within the spherical outer race at a considerable angle on either side of normal without binding or additional strain on the bearing parts. As a result, they are *quiet-running*, smooth-aligning and durable—solve problems which cannot be handled by ordinary radial bearings.

Federal Self-Aligning Double Row Radial Ball Bearings are made in light, extra-light, medium and heavy series; in regular and wide types for any load requirement; and in adapter and wide inner ring types for securing at any point along a plain or shoulderless shaft.

They're all described in our catalog "K," which covers the complete Federal line...every type and size, shielded and sealed...for every anti-friction need. (A few of the many types are shown here.) You'll also find ball bearing selection charts to help you compute bearing loads, determine capacities at every speed, and select the type and size ball bearing best suited to your application. Write today for your copy of this 260-page catalog.

THE FEDERAL BEARINGS CO., INC. • POUGHKEEPSIE, N. Y.

Makers of Fine Ball Bearings

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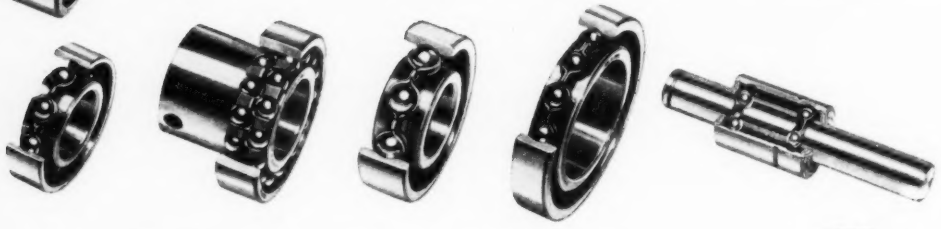
1120 Chester Avenue, Room 439, Chester-Twelfth Building, Cleveland 14, Ohio



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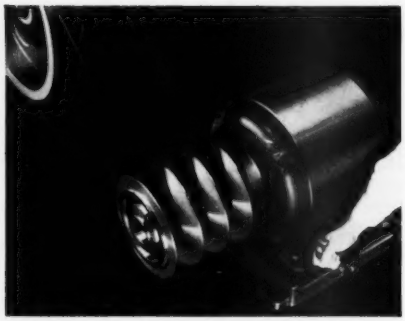
ALLIS-CHALMERS OFFERS EQUIPMENT

Tips on Economical

A-C ALLIS-CHALMERS

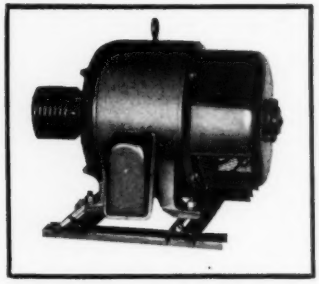


New! VARI-PITCH Automatic Sheaves

Accurate, instant speed control for most speed changing needs from 3 to 20 hp. Simply move the motor toward the driven sheave to increase machine speed . . . move it away to decrease speed. The automatic sheave does all the work. Lowest cost method of changing speeds while running.

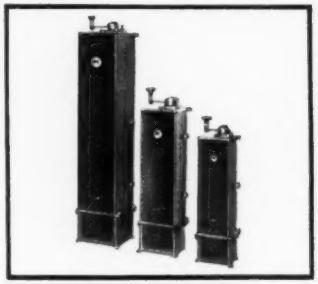
Here's a quick look at industry's widest range of adjustable speed equipment. From this line you can select a *type* of drive that will meet the exact requirements of your particular equipment . . . an *economical* drive, because you choose the *simplest, least costly* for your job!

Allis-Chalmers not only builds wide range adjustable speed equipment such as d-c motors and control, but also complete *Texrope* V-belt drives. For example, *Vari-Pitch* sheaves have a speed range of 2 to 1 per sheave . . . 4 to 1 per drive. They allow a wide range of adjustable speeds at only a fraction of the cost of other types of speed changing equipment.



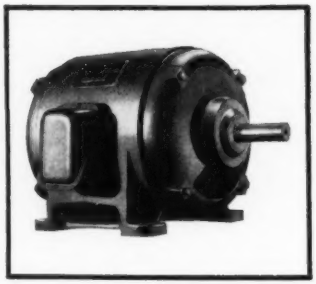
Direct Current Motors

Field resistance or armature voltage control applied to these motors give a practically stepless change of speeds over a wide range. Sizes from ½ to 200 horsepower and larger at all standard voltages. Available in such mechanical modifications as drip-proof, splash-proof and for vertical mounting. For constant and variable torque loads requiring speed adjustment.



Motor Controls

Wide range of wound rotor motor drums and resistors. Sizes from 5 to 750 horsepower in enclosed, general purpose, and semi-dust tight enclosures. For larger motors, motor operated drum controllers are available in a range of sizes. A new line of liquid slip rheostats for secondary control of wound rotor motors for use in special applications is also available.



Multi-Speed Motors

Constant torque, variable torque, and constant horsepower models in sizes from 1 to 75 horsepower. Available in either two or four speeds with overall range from 450 to 3600 rpm. Normal starting torque and current, and low starting current and high starting torque can be furnished. Combined with *Vari-Pitch* sheaves or speed changers, these motors offer wide speed range.

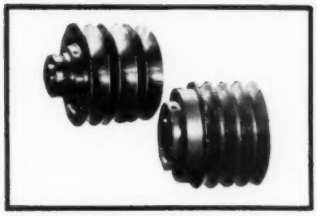
Texrope, Vari-Pitch and Regulex are Allis-Chalmers Trademarks.

Pioneers in Power and Electrical Equipment
From Generation Through Utilization

ALLIS

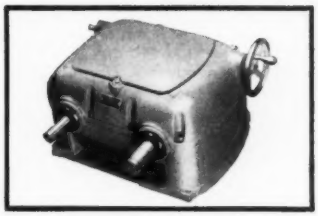
AID TO MACHINE DESIGNERS!

Adjustable Speed Drives



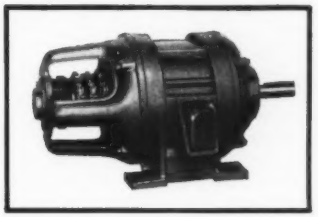
VARI-PITCH Sheaves

Standard Range *Vari-Pitch* sheaves have 15% to 25% range per sheave . . . Wide range *Vari-Pitch* sheaves 100% per sheave. Furnished in both stationary and motion control to suit application. These sheaves provide *stepless* speed changes at relatively low cost. Recommended for Textile Spinning Machines . . . Machine Tools . . . Heating and Ventilating Systems . . . others.



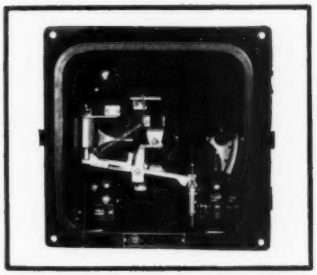
Speed Changers

Packaged speed control unit with simple handwheel for quick speed changes. Operates only in motion and provides instantly available variation of speeds through a smooth stepless range as high as 375%. Twelve sizes from 1 to 75 horsepower meet most requirements of modern machinery. This unit may also be driven through *Vari-Pitch* sheaves for even greater speed range.



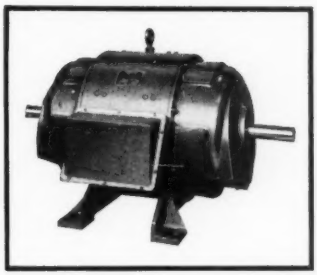
Wound Rotor Motors

For adjustable varying speed drives in sizes from 5 to 200 horsepower and larger. Wound rotor motors in conjunction with standard secondary controls offer a speed range down to 50% of synchronous speed. Starting torque characteristics of these motors make them ideal for jobs where low starting current and high starting torque are required.



Rocking Contact Voltage Regulators

Changing and holding a fixed speed on machines where the load is variable is effectively handled by Allis-Chalmers rocking contact voltage regulators. They consist of a solenoid or torque motor which rocks a hard graphite rocking contact sector against a commutator to change regulating resistance. A tachometer generator coupled to the motor shaft provides a measure of speed by supplying a voltage to the regulator coil proportional to motor speed.



REGULEX Rotating Amplifiers

Regulex amplifiers are used for speed regulation where field forcing and extremely fast response are required. *Regulex* machines provide strong corrective action because of high amplification of minute tachometer voltage changes, which has the effect of accurately and quickly controlling motor speed. These speed regulators can be used for hoists, or any drive where the load is variable and accurate speed control is needed. Can also be used for controlling almost any function of a machine which can be converted into volts, amperes or watts.

ALLIS-CHALMERS, 1002A SO. 70 ST. MILWAUKEE, WIS.

Please send me the literature checked below:

- Handy Guide for Electric Motors — Bulletin 51B6052 ☐
- Rocking Contact Voltage Regulators
  - Bulletin 14B6035 ☐
  - Bulletin 14B6143 ☐
  - Bulletin 14B6137 ☐
- *Regulex* Amplifiers — Catalog Section 6050 ☐
- *Vari-Pitch* Sheaves—Bulletin 20B6082 ☐
- Speed Changers—Bulletin 20B6013 ☐
- Switchgear and Control Devices Bulletin 25B7095 ☐
- Automatic *Vari-Pitch* Sheaves Section 20P50 Part 4 ☐
- Pre-Engineered *Texrope* Drives Bulletin 20B6956 ☐

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...ONE OF FOOTE BROS. COMPLETE LINE!

Hygrade enclosed gear drives

This famous line of worm gear drives has been newly engineered to offer the maximum in heavy-duty service and rugged dependability. These units now possess greater overhung load capacities.

Advanced methods in manufacture make possible new refinements in both worm and gear which assure extreme precision in the development of mating surfaces with a flawless finish. This gives longer life, smoother operation, quieter service.

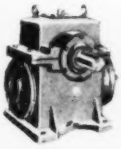
Hygrade Drives are available in both horizontal and vertical types. Single reduction ratios up to 71 to 1, capacities up to 125 h.p. Double reduction (helical-worm and double-worm) with ratios from 50 to 1 up to approximately 4000 to 1, capacities up to 50 h.p.

AVAILABLE FROM STOCK

Foote Bros. Hygrade Drives in more popular sizes and ratios are available from stock. Write for information.

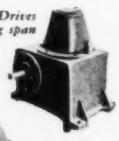
Hygrade Horizontal Drive

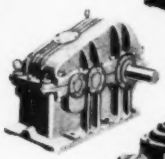
Hygrade Vertical Drives.



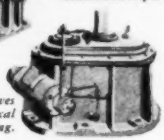
Hypower Drives bring new compactness in design, lower original cost, lower operating cost, through increased thermal capacity.

Hygrade Top Hat Drives have wider bearing span in the unit, permitting greater unsupported loads.





Maxi-Power Helical Gear Drives, available in single, double and triple reductions.



Agitator Drives combining helical and worm gearing.

Straight Line Drives. Designed for long life and quiet operation. Large overhung load capacities.

FOOTE BROS.

Better Power Transmission Through Better Gears

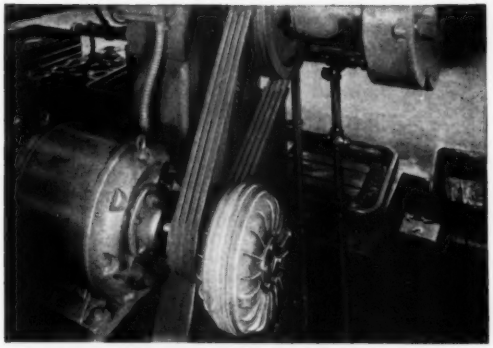
FOOTE BROS. GEAR AND MACHINE CORPORATION
4545 South Western Boulevard, Chicago 9, Illinois

Foote Bros. Gear and Machine Corporation
Dept. W, 4545 South Western Boulevard
Chicago 9, Illinois

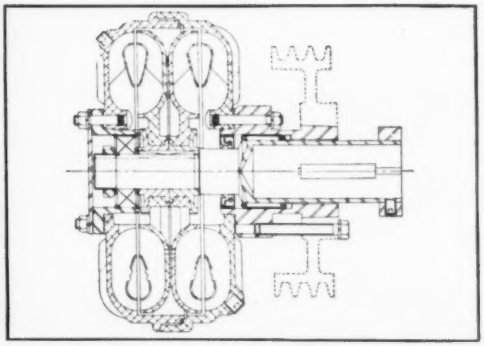
Gentlemen:
Please send me information on drives checked below.

- ☐ Hygrade Enclosed Worm Gear Drives
- ☐ Hypower Enclosed Worm Gear Drives
- ☐ Maxi-Power Enclosed Helical Gear Drives
- ☐ Agitator Drives
- ☐ Straight Line Enclosed Gear Drives

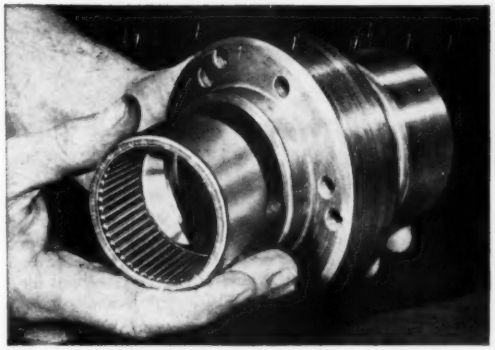
Torrington Needle Bearings Save Space and Give Dependable Service in Twin Disc Hydro-Sheave



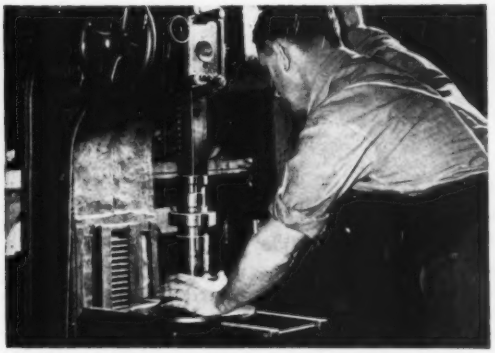
The Twin Disc Hydro-Sheave Drive, made by Twin Disc Clutch Company, permits smooth acceleration and prevents stalling of electric motors and internal combustion engines. Efficient power transmission is secured with compact Torrington Needle Bearings.



Cross-section shows location of the Needle Bearing under the sheave. The compactness of this bearing, with its small diameter rollers and thin outer race, makes it ideal for this application. Its oil reserve capacity eliminates need for pressure lubrication.

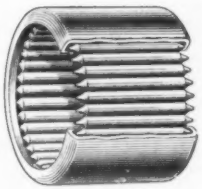


The full complement of precision rollers, operating on a hardened and ground shaft, provides tremendous load capacity. This feature, combined with the low coefficient of friction, assures reliable operation and long, trouble-free service life.



Needle Bearings are easily installed with a simple arbor press operation. The bearing takes a firm press fit, and therefore requires no retaining devices. Thus, to the advantages of compactness and efficient operation are added speed and economy of assembly.

Many machines can be made lighter, sturdier, more compact and more efficient with Torrington Needle Bearings. Our engineers will be glad to help you adapt these high capacity bearings to your equipment. Write us today. THE TORRINGTON COMPANY, Torrington, Conn., or South Bend 21, Ind. District offices and distributors in principal cities of United States and Canada.



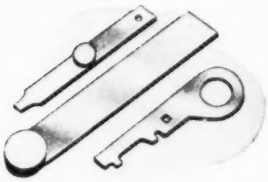
TORRINGTON *NEEDLE* **BEARINGS**

Needle • Spherical Roller • Tapered Roller

Straight Roller • Ball • Needle Rollers

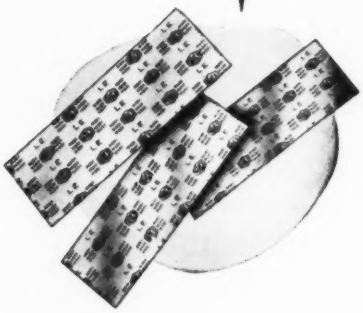
Triple Advantage

...of securing contacts



and thermometal

contact assemblies



from a single source–Wilco

It is *triply* to your advantage to rely on WILCO for electrical contacts, thermostatic bimetals and contact assemblies.

FIRST . . . WILCO offers you a wide range of electrical contacts in silver, tungsten, platinum, sintered powdered metals and in alloys and combinations of these — in solid and composite studs, rivets, screws and steel-backs.

SECOND . . . the facilities of THE H. A. WILSON COMPANY permit you to secure both electrical contacts and thermostatic bimetal from a single source for use as parts of the same device . . . *contact assemblies* designed and manufactured *under one roof* . . . combining the superfine quality of WILCO contact materials and WILCO thermometal to meet the highest performance standards.

THIRD . . . you obtain the cooperation of the WILCO Sales and Engineering Departments . . . who are thoroughly familiar with both electrical contact and thermometal application . . . and thoroughly equipped to help you achieve your objectives of reduced costs, improved performance or new product development. Whatever your requirements for contacts or contact assemblies, WILCO engineers will gladly help you meet them successfully.

WILCO PRODUCTS INCLUDE: THERMOSTATIC BIMETALS: All temperature ranges, deflection rates and electrical resistivities. ELECTRICAL CONTACTS: Silver, Platinum, Tungsten, Alloys, Sintered Powdered Metal. SILVER CLAD STEEL: For industrial use. NI-SPAN C* Constant Modulus Alloy; also low and high expanding Ni-Span Alloys. JACKETED WIRE: Silver on Steel, Copper, Invar and many other combinations. SPECIAL ALLOYS: Including high conductivity, high strength, Copper Alloys. ROLLED GOLD PLATE AND GOLD FILLED WIRE.

*REG. TRADE MARK, THE INTERNATIONAL NICKEL CO., INC.

THE H. A. WILSON COMPANY
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SPECIALISTS FOR 35 YEARS IN THE MANUFACTURE OF THERMOMETAL • ELECTRICAL CONTACTS • PRECIOUS METAL BIMETALLIC PRODUCTS AND SPECIAL ALLOYS

No Sale For Gingerbread

The seller's market is over. Money is tighter. Prospects are reluctant to buy. Why?

Because few quality products are offered at an acceptable price. Correct this last and the other conditions will be counteracted. The present recession will continue its downward trend until the fewer dollars in the consumers' pockets will buy more—more in quantity and more in quality.

Last month in a special report, PRODUCT ENGINEERING showed many redesigns that cut costs. In most instances the case studies referred to parts required to meet the established over-all design specifications of the product. But cost cutting doesn't begin at the detailer's drawing board. It begins when the product specifications are being decided. It is all very well for an engineer to cut the cost of a design feature to the bone, but the question should be: Is this feature essential or desirable in the first place? Can the whole gadget be thrown out with no harm to the salability of the unit? The answer to this last question today is vastly different from what it was a year ago, as illustrated by the designs of automobiles.

When cars were hard to get, the buyer was not asked whether he wanted a radio, or heater, powered window lifts, cigarette lighter, clock, fancy trim, bright chrome plate, rainbow colored horn buttons and a body that looked like a scow. Maybe the prospective buyer was physically able to raise and lower windows manually, didn't smoke, didn't want a heater for driving in Texas, wasn't interested in squeezing four people in the front seat or using the car to sleep in. Maybe he was one of those individuals who doesn't even care what time it is. In spite of all that, he had to pay for all the "gingerbread" whether he wanted it or not, or he didn't get the car. The effects on both seller and buyer were very bad. The former got arrogant and the latter disgruntled.

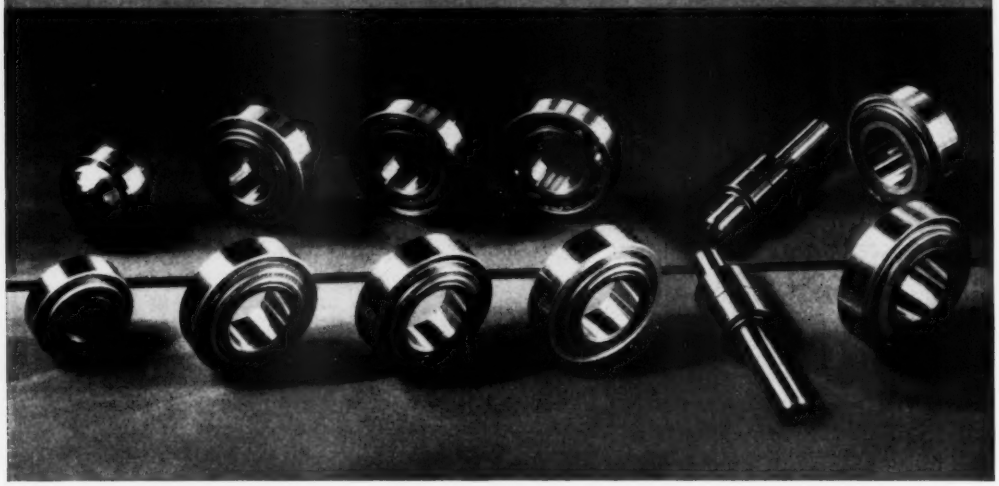
How long this recession will continue will depend largely on how soon manufacturers and sellers will recognize the fact that now they must conform to the dictates of a buyer's market. They must please the prospect, or there will be no sale.

In many instances, as in the case of the automobile, the prime requisite is to recognize that the need today is for products that are functionally sound, look the part and are without parasitical gingerbread. Savings achieved by eliminating nonessentials are cumulative and are usually far greater than can be obtained by ingenious design of unnecessary features. The demand today is for a decent looking automobile that will "take you there and bring you back." Features that contribute nothing to that specification and add to the price will find a cold reception. The flattened purses of the buying public will not tolerate nonessentials that serve no purpose except to give salesmen something to talk about.

What holds true for the automobile applies equally to all other consumer durable goods and also to some extent to capital goods. To be sure, the product must be functionally sound and look the part. It must possess worthwhile design features that contribute to ease of use, higher efficiency of operation and greater durability. But, the knickknacks and gingerbread that are draped on the product to attract sales will have a reverse effect. The people who still have money in their pockets are the smart ones who are not so easy to sell. They will demand their money's worth, and in their language that means cutting prices to the bone. Cutting out the gingerbread comes first in any cost reduction program.

G. F. Rodenholt

FIRST OF ALL . . .



The many types of sealed and lubricated-for-life ball bearings originated by New Departure, give unexcelled service, not just because they are protected from dirt and other destructive elements, but because *first of all* the basic bearing designs, the steels used and the manufacturing methods employed result in bearings of superior capacity and endurance.

They are then lubricated and sealed to protect and preserve these qualities by the best means that the widest experience in the industry can devise.

Nothing Rolls Like a Ball

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63-C

NEW DEPARTURE . Division of GENERAL MOTORS CORPORATION . BRISTOL, CONNECTICUT . BRANCHES IN ALL PRINCIPAL CITIES

The Glenn L. Martin Company

CHECKS AND BALANCES of the project-layout engineering team operate through periodic discussions and conferences.

A Plan for Effective Design Screening

Basing his philosophy on the maxim "A stitch in time," the author offers a plan for integrating and sequencing all engineering activities from initial idea to actual production.

GEORGE H. LOGAN
Consulting Engineer

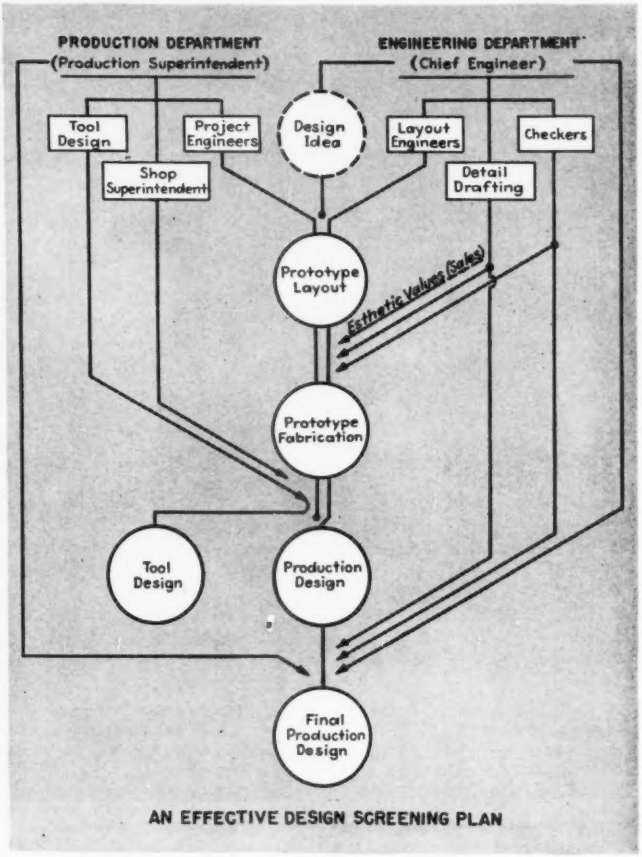
IT IS AN AXIOM that every hour spent on screening an engineering design before production will save at least 100 hours later.

How can this screening be accomplished most effectively and efficiently? A plan that has demonstrated its worth, especially in small industries doing an appreciable amount of development work, is herewith presented. It is a tailor-made system of synchronizing an organization's brains as a new design progresses from an ephemeral idea to final production prints.

Decision to initiate design for a new product, or to improve or modernize the design of an existing product, usually originates at the high level of management—often through sales department advice that there is a market to justify the development cost and effort. Management then undertakes marketing research to verify that this buyer-acceptance potential exists. If the go-ahead signal is given, the chief engineer is authorized to direct the application of appropriate intellects to the problem.

The one man with overall responsibility for such a creative effort is the chief engineer. He therefore is the man to pick the people and to launch the assignment, to follow the sequential flow shown in the accompanying chart.

The chief engineer formulates the essential parameters that apply to the design. It is also desirable that he conceive at least the skeletonized form of the new device; this can be presented as tentative freehand sketches or written notes. Ready with a design idea, his next step is to have a meeting with a layout engineer and a project engineer. Careful selection of these



AN EFFECTIVE DESIGN SCREENING PLAN

two is important. Their past experience should parallel as closely as possible the character of the proposed product.

At this meeting, the preliminary thinking accomplished by the chief engineer is delivered as a package to the project and layout engineers. Thereafter, and up to the final stage as shown by the chart, these two are to work as a team. Each is to act as a consultant to the other as the design synthesis moves forward. The chief engineer delegates the responsibility for actual execution of the design to the project-layout team. The chief engineer is subsequently involved, of course, but only for cursory checks during progress of the assignment; and for a rigorous check during creation of the final production design, as discussed later.

The first joint activity of the team is to draw up the prototype layout. Naturally, most of the actual drafting is done by the layout engineer. The project engineer is responsible for the "hardware" activities. A practical man, the project engineer will have much to contribute to the budding assembly drawings. All practical technicians have experienced the unfortunate paradox that a beautiful drawing is now necessarily the best drawing; that elements which look functional on paper often are almost impossible to put together and take apart when converted to "hardware". The layout engineer taps his own background in machine design and mathematics; concurrently the project engineer colors the growing layout with practical simplifications, with his knowledge of the possibilities and limitations of fabricating machines. The system of continuous checks and improvements is under way.

As soon as the layouts are ready for exhibition, a representative of the sales department is invited to present a critique of the design from the "esthetic" standpoint, which he does simply by asking: "Are the prospective buyers going to like the looks of this gadget?"

It is imperative that the sales department has a voice at this stage. A few minutes of constructive appearance criticism at this time can save thousands of dollars spent on belated redesign for customer appeal.

The project-layout team should be in good debating form during these visits, for the sales department will sometimes advocate sacrificing functionalism and low cost in order to give the embryo product more "appeal". It is not unusual for the chief engineer to add his voice as moderator. However, out of these sessions must come acceptable compromise. The theme of such discussions should be: "The best looking device can be the most economical and best operating device." If engineers delve deep enough, they will find that this theme almost invariably pays off.

When the sales representative is satisfied, the prototype layout is ready for detailing, incorporating the agreed revisions. But the detailing should not be just a routine procedure. The detail draftsman, who usually has aspirations of rising to layout engineer, should be encouraged to take a critical approach, and to propose modifications of the prototype design as he works. Thus, valuable ideas will often come into being, and the operation of teamwork will assure that the suggestion is absorbed. The same principle applies when the checker steps in.

Prototype fabrication then starts under the supervision of the project engineer. Now the layout engineer need give only a moderate amount of his time as hardware builds up. But he is still an active member of the team, and through intermittent observation and a questioning frame of mind, he will accumulate notes for further simplification and improvement. He may evolve some of these ideas in time to be included in the prototype hardware.

Prototypes are either single units or few in number, and they should be constructed with a bare minimum of special tooling. Some special tooling will probably be deemed mandatory, but it is best in the long run if it be of a temporary and inexpensive character. The obvious reason for this philosophy is that the design is not yet completely jelled. It is advisable to make the assumption that some changes will be made after the prototype is finished. To obviate costly changes in special tooling, the

manufacture of such accessories should be delayed until a thoroughly acceptable prototype is produced.

Some departure from this philosophy may be made necessary by a tight delivery schedule. If actual orders for the new product are on hand, the earliness of the delivery date may necessitate starting fabrication of production and assembly tooling prior to the completion of the prototype. Good judgment will decide such questions.

When the curtain rises on the completed prototype, the team calls a meeting, inviting the shop superintendent and the assigned tool designer. The main objective of this conference will be to visualize appropriate tooling, and to plan the class of tooling in accordance with expected sales volume. But the alert team will not let them get off that easily. The project-layout team will vigorously "pump" their guests, particularly the shop superintendent: "How can this, that, and the other element be made cheaper, faster, better? Will this specified steel machine or form as easily as another acceptable steel? Will a slight design change here or there facilitate the production job? Can you hold these tolerances easily in production?"

This get-together will unfailingly produce some improvements, perhaps expose some hitherto overlooked design errors. Back to the board journeys the layout engineer, armed with copious notes and sketches he has acquired along the chart's route. At this point the project engineer should be able to leave the team, for the steps now remaining up to the final production design are few and easy.

The layout engineer again solicits the help of the assigned detail draftsman and checker. Now the complete set of final production drawings is detailed and checked. Although change recommendations are still welcome, those proffered at this stage will usually be minor and few. The preceding check-steps have by now reduced the design to a refined entity.

The final step on the chart (and frequently it will seem to be the most difficult) is to find a moment at which the chief engineer and production superintendent are not simultaneously swamped with other duties, and secure concurrent approval of the design package. Their evaluation of the design at this time constitutes the final screening. "Rank hath its privileges," and it will be a miracle if the two do not come up with a few change requests. These should be injected at once, not when the wheels are rolling.

Portable Instruments Require Increased Shielding

THE INFLUENCE of stray external magnetic fields on the field of portable electrical instruments is often sufficiently strong to cause gross errors in meter readings. To determine the extent of such fields and how to minimize their effects on voltmeters, ammeters and wattmeters, an investigation of a representative group of commercial portable instruments was undertaken by A. E. Peterson and associates of the National Bureau of Standards. A brief study was also made of stray fields existing around the more common kinds of laboratory apparatus.

For this investigation, test instruments were placed in magnetic fields of known magnitude, direction and phase angle. The fields were produced by a pair of Helmholtz coils consisting of two matched circular coils one meter in diameter spaced axially one-half meter apart. A field uniform to within 3 percent was thus established in a volume large enough to accommodate the largest of the test instruments. Coils were gimbal-mounted, allowing the axis to be swung to any desired azimuth and elevation.

Twenty-five instruments were tested in fields ranging from 1 to 10 gausses. In each case, the direction of the field and the phase angle with respect to the current in the test instrument were adjusted to produce the maximum deflection. The change in reading produced by a 180-deg reversal of the field was noted for each field-strength value. One-half of this change, expressed as a percentage of full-scale reading, was taken as the value of the magnetic-field influence.

In summarizing the results of the tests, the magnetic-field influence was compared with the manufacturer's figure for the stated accuracy of the instrument. The latter figure, an index of the quality of the instrument, does not generally take into account susceptibility to magnetic fields. This is especially true of unshielded instruments, the accuracy figure of which can be completely invalidated by stray fields of low strength.

On this comparison basis, an analysis of the test results revealed the following: (1) Of eleven moving-iron-type instruments tested, seven exhibited field influence values within their accuracy figures in a 1-gauss field. (2) Of seven permanent-magnet moving-coil instruments tested, two, having unshielded low-coercivity magnets, were affected to a degree comparable to their accuracy figures when subjected to fields of less than 1-gauss; the other five, having high-coercivity magnets or low-coercivity magnets combined with good shielding, behaved in a similar manner and could withstand 5-gauss fields or stronger without showing field influences greater than their accuracy figures. (3) Of seven electro-dynamic instruments investigated, one (unshielded) in a 1-gauss field showed a field influence of 0.9 percent, nearly equal to its 1 percent accuracy figure; while two of the six still met this qualification in a 5-gauss field.

In making a laboratory survey of stray alternating fields, Bureau engineers used a small search coil whose pickup voltage was measured with an electronic voltmeter. The magnetic field was readily computed from this voltage, the frequency and the area-turn constant of the coil. A small commercial gauss meter was used for direct fields.

Of the laboratory apparatus surveyed, only a few items indicated fields as large as one gauss at distances of 10 centimeters. This equipment included the larger rotating machines, a 1-kva voltage-stabilizing transformer, a 2- and a 7-kva adjustable-ratio autotransformer, and some of the tubular rheostats wound on magnetic tubes or having magnetic tie or slider rods. Stray fields about the adjustable-ratio auto-transformers were found to depend on the loading and the proportion of the winding that is tapped. For such apparatus, spacings of one-half meter were generally adequate to reduce the stray field well below one gauss.

The Bureau's investigations indicated that the chief factor regarding the effect of stray fields on instruments lies in failure to recognize such effects and in not taking steps to avoid them. In addition, conductors carrying heavy currents can also be a disturbing source of stray-field trouble in the laboratory. Placing such conductors as close to one another as possible, twisting them together and otherwise avoiding open loops, will usually reduce stray fields to a low value.

Bell Telephone Laboratories

Fig. 1—Magnetic cores of one mil 4-79 Mo Permalloy tape and partially assembled non-linear inductance in which they are used. Core stacks are 30, 2, and 1 lb in weight. These new materials increase effectiveness of electrical equipment.

Soft Magnetic Materials

Composition and heat treatment determine the magnetic properties of the soft (non-permanent) magnetic materials. These include magnetic iron, silicon steel, nickel-iron alloys, iron-cobalt alloys, iron-nickel-cobalt alloys, and the mixed ferrites.

E. A. GAUGLER
U. S. Naval Ordnance Laboratory

"Soft" magnetic materials are those having a relatively high permeability and a low coercive force. By constrast, permanent or "hard" magnetic materials have a relatively low permeability and high coercive force. This terminology originated because it described both the magnetic and mechanical properties of the material. In recent years notable exceptions have been found and these terms have lost their dual significance. (See "Permanent Magnet Stability," PRODUCT ENGINEERING, Nov. and Dec. 1948.)

To insure optimum magnetic performance of soft magnetic materials, the designer should be familiar with the following factors: Composition, heat treatment, mechanical stress, grain orientation, temperature, frequency, and magnetic circuit design. Some of these variables are controlled directly, while others are controlled indirectly through selection of the materials.

Composition

Most soft magnetic materials contain the ferromagnetic elements—iron, nickel, and cobalt—in various combinations. Sometimes certain non-ferromagnetic elements, such as silicon, molybdenum, chromium, and copper are added. Magnetic properties of commercially available magnetic materials are shown in Table I. Other physical and electrical properties such as density and resistivity are added because they are useful in design.

In addition to the major constituents, the amounts and types of impurities in the material have a profound effect on magnetic characteristics. These impurities may be in the raw materials, or may be introduced during melting and heat treating. In general, greatly superior results can be attained by reducing impurities such as carbon, silicon, sulfur and phosphorus. When the best results are required, pure raw materials are alloyed in a vacuum or controlled atmosphere induction melting furnace. Final annealing is

Table I—Typical Magnetic Properties of Commercial Grade Soft Magnetic Materials Measured by D-C Tests

Name	Composition, Percent	Heat Treatment	Permeability		Coercive Force, H_c, oersteds	Saturation Induction, B_m, gauss	Electrical Resistivity, microhm-cm	Curie Point, C	Density, g/cc	Uses
			Initial μ_o	Maximum μ_m						
Iron	99.9 Fe	900C	200	5,000	1.0	21,500	10	770	7.87	Yokes for electromagnets
Silicon iron	4 Si, 96 Fe	800 C	400 (at $B=20$)	7,000	0.6	19,700	59	690	7.60	Power transformers
Silicon iron	3.3 Si, 97 Fe	Cold rolled, 800 C	600 (at $B=20$)	10,000	0.2	20,000	50	700	7.65	Power transformers
Grain-oriented silicon iron	3.3 Si, 97 Fe	Cold rolled, 1,200 C, H_2	1,500 (at $B=20$)	40,000	0.1	20,000	48	700	7.65	Power transformers
45 Permalloy	45 Ni, 54 Fe	1,050 C	2,500	25,000	0.3	16,000	50	440	8.17	Transformers, relays
Hipernik	50 Ni, 50 Fe	1,200 C, H_2	4,000	80,000	0.05	16,000	45	500	8.3	Transformers
Conpernik	50 Ni, 50 Fe	650 C	1,500	2,000	0.5 (for $B_m=10,000$)	16,000	45	500	8.3	Reactors
Orthonol	50 Fe, 50 Ni	Cold reduced 1,050 C, H_2	700 (at $B=20$)	170,000	0.07	15,500 ($B_r=14,800$)	45	500	8.25	Mechanical rectifiers, magnetic amplifiers
Monimax	47 Ni, 3 Mo, bal. Fe	1,100 C	2,000	37,000		15,000	80		8.25	Pulse transformers
Sinimax	42 Ni, 3 Si, bal. Fe	1,100 C	3,500	34,000		11,000	90		7.65	Pulse transformers
78 Permalloy	78 No, 21 Fe	1,050 C, 600 C	8,000	100,000	0.05	10,000	16	580	8.60	Sensitive relays
4-79 Permalloy	79 Ni, 4 Mo, 16 Fe	1,100 C	20,000	80,000	0.05	8,700	57	420	8.72	Magnetic shields
Mumetal	75 Ni, 2 Cr, 5 Cu, 18 Fe	1,100 C, H_2	20,000	110,000	0.03	7,200	60	430	8.58	Audio transformers
Supermalloy	79 Ni, 5 Mo, 15 Fe	1,300 C, H_2	100,000	800,000	0.004	8,000	60	400	8.87	Video transformers
Permendur	50 Co, 50 Fe	800 C	800	5,000	2.0	24,500	7	980	8.3	Electromagnets
V-Permendur	49 Co, 2 V, 49 Fe	800 C	800	4,500	2.0	24,000	26	980	8.2	Telephone diaphragms
Hiperco	34.5–35.5 Co, 0.4–0.5 Cr, bal. Fe		650	10,000	1.0	24,200	22–34		8.0	Transformers, motors
7.5–45–25–Mo Permivar	7.5 Mo, 45 Ni, 25 Co, 21.9 Fe	1,000 C and 425 C bake	550	3,800	0.6	10,300	80	540	8.66	Telephone cables
Powdered Permalloy	81 Ni, 2 Mo, 17 Fe	Pressed; 650 C	125	130			10^6	480	7.8	Loading coils
Powdered iron	Insulated iron dust (Grade HP carbonyl)	Pressed	80	150					7.4	Permeability tuning
Ferrite	Mn-Zn Ferrite		700	910	0.6	3,000	10^{13}	90		Filter coils

preferably done in pure dry hydrogen close to the melting point. Unfortunately, these refined techniques are not ordinarily utilized in the commercial production of these materials. The large variation in properties of commercial materials could be eliminated if precautions were taken to control impurities.

MAGNETIC IRON. Soft iron used for magnetic purposes is of high purity, better than 99.8 percent, and relatively inexpensive. Although it can be rolled into thin sheets, it is not suitable for a-c applications because of its low resistivity. Because its permeability at high flux densities is high it is particularly suited for yokes of electromagnets, field frames and pole pieces. Because of the action of certain impurities, this material is subject to "magnetic aging" to the extent that it cannot be used for certain critical applications. It is not uncommon to find increases in the coercive force and hysteresis loss in excess of 100 percent over a period of time. The silicon steels are not as susceptible to aging, and they have largely replaced magnetic iron in applications where aging is important.

Another form of iron is used in insulated pressed powder cores. Good grades of iron powder vary in size from 80 mesh to 3 microns, depending on the application frequency. The particles are coated with an insulating material such as a phenolic lacquer and molded into cores at pressures from 30 to 100 tons per sq in.

In some applications the permeability is purposely decreased, by diluting the mixture, because a higher Q (ratio of reactance to resistance) can be obtained at high frequencies due to the corresponding reduction of hysteresis and eddy current losses. The permeability of these materials is relatively low. Principal applications are in slugs used for permeability tuning and in loading coils.

SILICON STEEL. The addition of silicon to iron increases its resistivity, permeability, and reduces the core loss, saturation, and aging. However, silicon makes the metal brittle and difficult to machine. For punching into laminations the silicon content should be no more than 5.0 percent. Where machine operations are necessary, silicon content under 1.0 percent is preferred.

The magnetic characteristics of silicon steel are greatly affected by im-

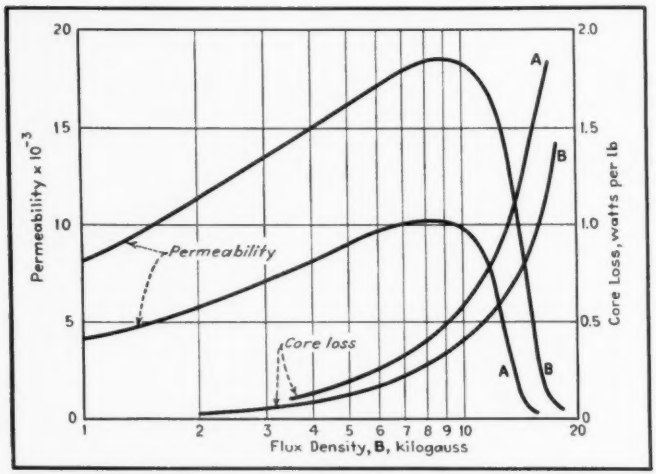


Fig. 2—Magnetic properties of grain oriented silicon steel are better in direction of rolling, than across the grain. Flux direction must parallel material's preferred axis.

purities and a far superior steel can be obtained by proper purification. The commercial grades are usually selected and sold under watt loss specifications rather than by composition. Cold rolled strip has better surface conditions and magnetic characteristics than hot rolled material. Silicon steel is widely used in power equipment such as motors, generators and transformers, and in low cost audio transformers where high quality is not essential.

A grain oriented silicon steel is commercially available. The core loss at high flux densities has been substantially decreased by cold reduction of a purified material followed by annealing in pure dry hydrogen. Because the material is grain oriented, it is important that the direction of the flux be along the preferred axis of the material—parallel to the direction of rolling—because, as shown in Fig. 2, magnetic properties are better in this direction. Thus, its principal use is in power transformers where laminated core construction is used; the length of the legs in the preferred direction are extended and the cross grain legs are shortened and widened to compensate for its decreased permeability. This material is sold under the trade names of Silectron, Hipersil, and Trancor X; these are heat treated and insulated at the mill. After fabrication it should be given a stress relieving anneal as 800 C in a neutral non-carburizing atmosphere.

NICKEL-IRON ALLOYS. The nickel-iron alloys are used where high permeability and low core loss are required. Since they are considerably more expensive than the silicon steels, they are used where these features outweigh the added cost. A number of different compositions are available commercially. In general, the nickel content falls in one of two ranges. 45-50 and 75-81 percent nickel.

45-50 PERCENT NICKEL ALLOYS. This material has a relatively high saturation and low core loss. Its specific resistance is high and it can be readily machined or punched before the final anneal. It is generally used in audio transformers and relays operating at high flux densities. It is sold under the trade names of 45 Permalloy, Allegheny Electric Metal 4750, Carpenter 49, Nicaloi, Armco Electrical Alloy 48, and Hipernik. The latter is available in modified form, as Conpernik, in which the permeability in flux densities from zero to 200 gauss does not change by more than 10 percent. Its hysteresis in this region is substantially reduced. These characteristics are obtained by annealing the alloy at a relatively low temperature after cold rolling. It is especially useful in choke coils that have a large d-c component of current and in coils requiring high Q at audio frequencies.

A grain oriented 50 nickel-50 iron alloy has recently been introduced in this country. This material is subjected to a drastic 99 percent cold reduction, followed by special annealing in pure dry hydrogen. Depending on the annealing temperature either a rectangular hysteresis loop or a conventional hysteresis loop can be obtained as is shown in Fig. 3. The rectangular hysteresis loop is particularly suitable for mechanical rectifiers, magnetic amplifiers, and saturable reactors. This material is known as Orthonol, Permenorm 5000-Z, Deltamax, Orthonik, and Hipernik V.

For high frequency applications such as pulse transformers and video transformers, it is desirable to increase the specific resistance at the expense of somewhat lower permeability and saturation. This can be accomplished by the addition of a third constituent such as molybdenum or silicon. This in-

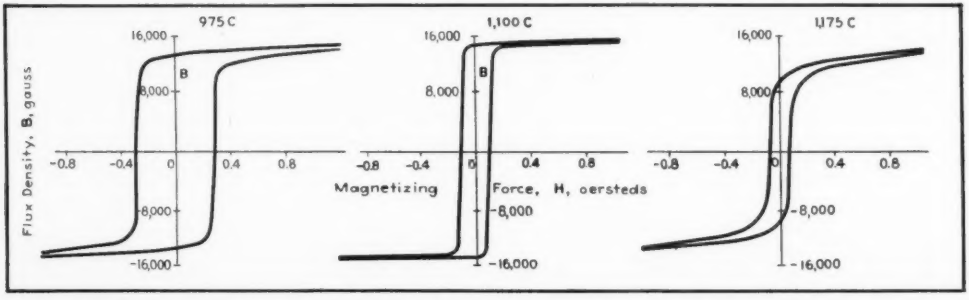


Fig. 3—Annealing temperature determines shape of hysteresis loop. This material, a grain oriented 50 nickel-50 iron alloy (Permenorm 5000-Z), was given three different annealing treatments, each at the temperature shown for two hours.

creases its specific resistance from 52 to 80 and 90 microhm-cm respectively. These materials are known commercially as 4-43 Permalloy, Monimax, and Sinimax.

75-81 PERCENT NICKEL ALLOYS. This composition is particularly suitable where high initial permeability is desired. Known as 78.5 Permalloy, it has higher maximum permeability and lower hysteresis loss than any of the other commercial nickel-iron alloys. The binary alloy has a relatively low resistivity and must be cooled rapidly to obtain good magnetic properties. It is particularly useful in relays and shields when low resistivity is desirable or can be tolerated.

When third constituents such as molybdenum or chromium are added, the effect is to increase its specific resistance and to reduce the cooling rate necessary to obtain desirable properties. This greatly simplifies the heat treatment. When 4 percent molybdenum is added the alloy is known as 4-79 Mo Permalloy and Carpenter Hymu 80. If 5 percent copper and 2 percent chromium are added, the alloy is known as Mumetal. These materials have replaced 78.5 Permalloy in most applications. They are used extensively in low level audio transformers and reactors.

As previously mentioned, magnetic materials can be greatly improved by purification. By taking special precautions in melting and heat treating in pure dry hydrogen at elevated temperatures (1,300 C) followed by controlled cooling rates, a greatly superior material is obtained. This material is known as Supermalloy and contains 5 percent molybdenum, 79 percent nickel, balance iron. Initial permeabilities of 100,000 and maximum permeabilities of 800,000 are obtained. This material can be used to advantage in pulse and video transformers. In the latter, because of its high permeability, the turns can be greatly reduced, thereby reducing capacitance effects which extend over the upper frequency range. This material is not yet commercially available, but will be in the future.

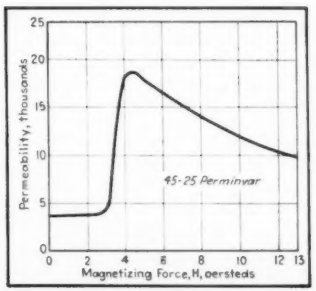


Fig. 4—Constant permeability at low flux densities is demonstrated by this alloy.

A composition of 2-81 Mo Permalloy is available in dust form, ranging from 120 to -325 mesh. Recently 4-79 Permalloy has also been produced by another process in sizes ranging from 80 mesh to 8 microns. The dust is usually insulated with talc or kaolin and pressed into cores at pressures up to 100 tons per sq in. A diluent can be added to increase the "Q" at high frequencies. It is subsequently annealed at 650 C to decrease the hysteresis loss. Although the permeability is low compared to the same material in sheet form, it has substantially higher permeability than iron dust and much lower hysteresis loss. Its principal uses are in loading coils and filters.

IRON-COBALT ALLOYS. Some of the iron-cobalt alloys exhibit the highest saturation flux densities of any known material. The maximum saturation is obtained in the region of 35-40 percent cobalt alloy. The 50 percent cobalt alloy, commercially known as Permendur, is preferred for most applications because its high saturation can be obtained at substantially lower magnetizing forces. The binary alloys in this range are brittle and difficult to roll. They are available only in heavy sections and are used in electromagnets and permanent magnets as yokes and pole pieces.

If 2 percent vanadium is added to the 50 percent cobalt-iron alloy, the metal can be rolled into thin sheets, and is known as V-Permendur. This addition increases its specific resistivity but only slightly lowers the saturation. It is used in telephone diaphragms and magnetostriction transducers. Another iron-cobalt alloy containing 35 percent cobalt and a small percentage of chromium is known as Hiperco.

IRON-NICKEL-COBALT ALLOYS. Some of these alloys have constant permeability at low flux densities, as illustrated in Fig. 4, and extremely low hysteresis loss. One composition, 30 iron-25 cobalt-45 nickel, is known as 45-25 Perminvar. To obtain these special characteristics the material is baked for several hours at a relatively low temperature (350 to 500 C), after the usual high temperature anneal. This material responds markedly to magnetic annealing and a rectangular hysteresis loop is obtained. Because of its relatively low resistivity it cannot be used in magnetic and mechanical rectifiers without further modification. With the addition of 7.5 percent molybdenum its specific resistance can be raised at the expense of a lower saturation. Because of its constancy of permeability and low hysteresis loss this material should be excellent for use in loading coils, continuous loading of telephone cable, and applications where high Q's are needed at audio frequencies.

FERRITES. Recently a new class of magnetic materials known as mixed ferrites have been developed. Because of their ceramic nature, eddy currents have been practically eliminated. Their hysteresis loss is relatively low, but

MAGNETIC TERMINOLOGY

Magnetic field intensity, H—magnetizing force in oersteds (ampere-turns per 1.257 cm).

Flux density or Magnetic induction, B—lines of flux per square centimeter (gauss).

Permeability, μ—the ability of a material to become magnetized when placed in a magnetic field:

$$\mu = \frac{B}{H}$$

Reactance, X_L—the impedance of a pure inductance to an a-c current:

$$X_L = 2\pi fL$$

where f = frequency
L = inductance

Choke coil or Reactor—a large inductance used to smooth out an a-c wave.

Saturation—maximum flux density that a piece of magnetic material can carry.

Space factor—the ratio of the volume of the core material itself to the volume of the core as a whole which includes insulation and air space.

Coercive force, H—magnetic field intensity required to reduce flux density to zero.

Hysteresis loss—energy loss when a magnetic material is cycled in a magnetic field.

Eddy current loss—energy loss caused by eddy currents induced in the core material by cycling in a magnetic field.

Specific resistance—resistance across parallel faces of a cube of the material one cm on each side.

Pulse and video transformers—transformers used over a wide band high frequency range.

Band pass filter coils—coils used in a filter circuit designed to pass a specific band of frequencies.

Residual induction, B_r—flux density that remains in a magnetic material when the magnetic field intensity is reduced to zero.

Maximum induction, B_m—maximum operating flux density.

Minimum induction, B_n—minimum operating flux density.

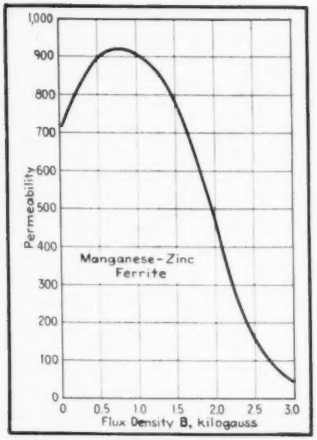


Fig. 5—Characteristic curve of permeability vs. flux density for Mn-Za ferrite

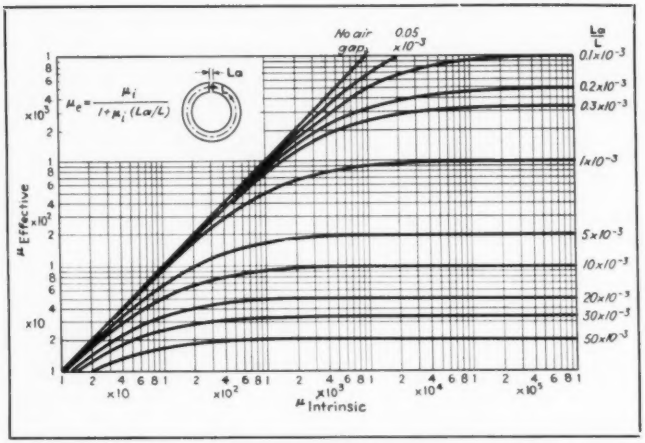


Fig. 6—Introduction of an air gap reduces effective permeability. Mu effective of a material with air gap is maintrinsic of an equivalent closed ring sample.

the residual loss rises rapidly above 500 kc. Made of an intimate mixture of oxides, cores are pressed at relatively low pressures, and heat treated in a controlled oxidizing atmosphere. With manganese-zinc ferrite a maximum permeability of 1,000 and a specific resistance of 10^{13} microhm-cm can be obtained. Fig. 5 shows a characteristic curve for this material.

The principal disadvantage of these materials is their low Curie temperature. For example, manganese-zinc ferrite has a Curie temperature of 120 C. Below that temperature the permeability changes rapidly. This undesirable feature should be investigated before it is used in certain applications. However, these materials are relatively new and it is probable that many improvements will be made. Mixed ferrites are known commercially as Ferroxcube and Cerromag. At present they have limited use in bandpass filter coils and permeability tuners.

Heat Treatment

Soft magnetic materials should be annealed after all fabricating operations have been completed. This increases their permeability and decreases their hysteresis loss. Annealing is most effective with high permeability materials. A 500-fold increase in permeability is not uncommon for some of the nickel-iron alloys.

One purpose of the final anneal is to relieve mechanical strains in the material. However, suitable precautions must be taken to prevent oxidation of the charge. Oxidation produces undesirable surface scaling and severely impairs magnetic properties.

One of the simplest heat treating methods is pot annealing; the charge is sealed in a nichrome pot with copper wool, iron dust, or other materials, to burn out the oxygen at relatively low temperatures. However, far superior results can usually be obtained by annealing in a pure dry hydrogen atmosphere. In this method oxidation is prevented and certain undesirable impurities are removed from the material. Commercial grades of electrolytic hydrogen are not satisfactory for magnetic work without further purification. For superior results, the oxygen and water vapor in the furnace atmosphere should be reduced to below one part per hundred thousand. This can be done by burning the oxygen over a palladium catalyst and absorbing the water in activated alumina.

Best results can be obtained by annealing close to the melting point of the metal. This is not usually practical and most annealing is done at approximately 1,050 C with good results. The charge is held at this temperature at least long enough to insure uniform heating, generally from 2 to 4 hr. The subsequent cooling rate is important for some alloys. For example, with 4-70 Permalloy, rapid or slow cooling depends on whether the initial or maximum permeability is to be increased. In any case, the cooling should not introduce strains.

Insulation

Insulation should be thin and uniform to maintain a good space factor. Although laminations have been coated with lacquers, varnishes, and paper, the resulting space factor is not high.

One of the most commonly used methods of insulation is light oxidation of the surface. This can be conveniently applied at the end of the annealing cycle or by subsequent heat treating. Since oxidation is usually detrimental to magnetic properties, it is essential that this be done properly, and at the right temperature. The oxidation is usually done below 550 C for nickel-iron alloys.

The ideal type of insulation is a refractory that can be applied prior to annealing and will prevent sticking during the annealing operations. Various materials, such as magnesium oxide, aluminum oxide, and mica dust suspended in a volatile liquid, have been used. When mica dust is used with laminations, the unpunched strip is coated and the mica acts as a die lubricant during punching, thereby increasing die life. During the anneal it is converted into a complex silicate which insulates the laminations.

Another method of insulation uses a cataphoresis coating, an electrochemical deposit of fine colloidal particles. The strip is passed through a mixture of silicic acid and acetone. A potential of 5 to 45 volts is applied between the tape and container, the tape having the positive potential, and the particles are plated uniformly on the tape. The silicic acid is broken down to silica during the final anneal. Unfortunately, these refractory coatings adversely affect the magnetic characteristics to some extent. This should be investigated before a particular coating is chosen.

Wound Cores

When grain oriented materials are used in transformers, the wound type core is preferred. Also, when thin ma-

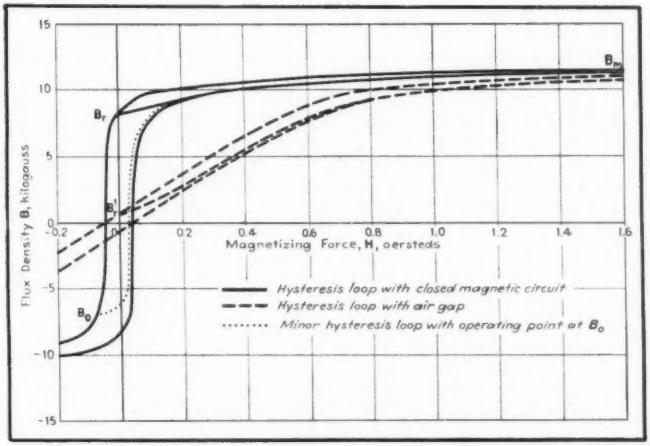


Fig. 7—Shearing of hysteresis loop by introducing an air gap. Where non-linear properties of magnetic materials are utilized, cores without air gaps must be used.

terial of 0.003 in. and less is employed, it is usually not practical to punch it into laminations, since close die clearances must be maintained. It is difficult to avoid mechanical strains during subsequent handling and mounting after annealing with thin laminations. The wound type of core construction is efficient, since a high space factor can be maintained, and the air gap is negligible in an uncut core. Using mechanical winding techniques, space factors ranging from 80 to 90 percent can be obtained, using 0.003 in. material.

For some materials the windings should not be put directly on the annealed core. Preferably, the core should be mounted in an insulating container which supports the windings and prevents mechanical straining of the core. Another possibility is to impregnate the core with a plastic binder, although this is usually detrimental to the magnetic quality of the high permeability materials because it introduces mechanical strains.

Sometimes it is desirable to cut the core to facilitate winding or provide a needed air gap. This can be done by first vacuum impregnating the core with a plastic bonding material. After baking, the plastic sets and the core is a rigid body. It can then be cut on a carborundum wheel. The complete core is held together by a soldered metal band. If properly done, an air gap of less than 0.0005 in. per gap will result.

Magnetic Circuit

To effectively utilize the high permeability property of materials, it is essential that there be no air gaps in the magnetic circuit. Fig. 6 shows how the effective permeability of a material is reduced by air gaps. In magnetic amplifiers, where the non-linear properties of magnetic materials are utilized, either wound or laminated cores without air gaps give optimum results.

The effect of air gaps is to shear over the hysteresis loop as shown in Fig. 7. Thus, the residual induction B_r is decreased to B'_r, and the magnetizing force for a given flux density is increased. This can be used to advantage when the core is excited by undirectional voltage pulses, as in certain pulse transformers. Regardless of the initial magnetic condition of the specimen, after subsequent undirectional pulsing, the core will operate between the residual induction B'_r and a maximum induction of B_m. Since air gaps decrease B'_r, the operating range of this type of pulse transformer will be increased. The air gap should be properly determined to get maximum permeability in the operating range.

However, even a greater flux change and higher efficiency could be obtained by a negative bias or a reset operation such as a charging current between pulses. The operating range could then be from B_o to B_m as shown in Fig. 7. If it is required that an inductance operate with a high d-c biasing field as in filter chokes, a properly selected air gap will increase the permeability at high magnetizing forces, because of the shearing of the hysteresis loop.

An air gap can also be effectively used when a high Q is required at a specific frequency. By the introduction of a properly controlled air gap, the effective permeability of the material can be controlled. This will also result in decreased flux density when the material is excited at a fixed amplitude of magnetizing force. Since both eddy current and hysteresis losses are also functions of flux density, an optimum air gap can be selected which will result in the maximum Q at a given frequency. This is used in pressed powder cores by regulating the diluent, and in transformers and inductances by air gaps in the magnetic path.

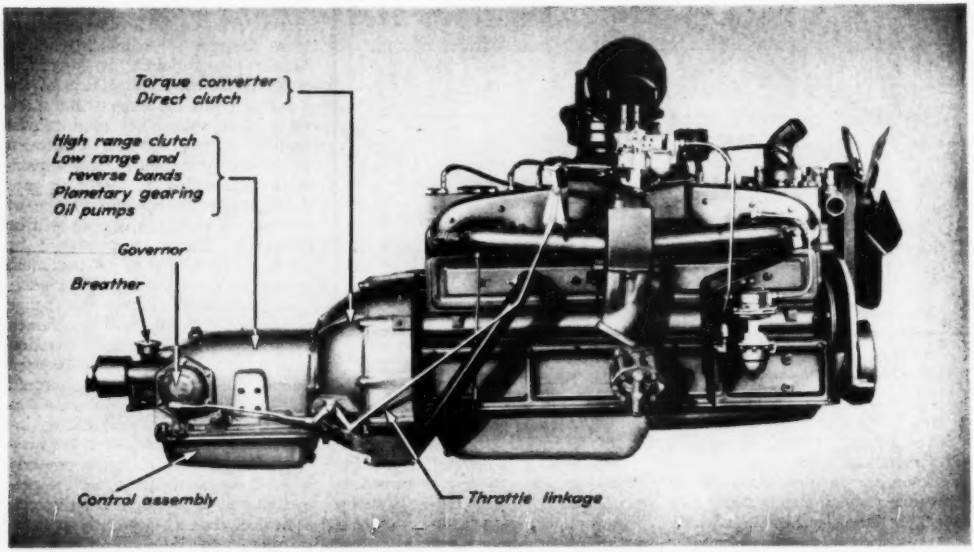
Abstracts of European Technology to Be Published

A NEW SUBJECT INDEX and abstract collection of more than one thousand unclassified scientific and technical reports prepared by the Combined Intelligence Objectives Subcommittee and dealing with European technology can now be obtained from the Office of Technical Services or the Department of Commerce.

Of interest to librarians and technical research workers, working in a variety of design fields, this publication of the Joint Chiefs of Staff is the first in a series of such volumes. Eventually this reference material will include reports of the British Intelligence Objectives Subcommittee (B.I.O.S.) and Field Intelligence Agency Technical (F.I.A.T.) as well as a group of minor reports, all dealing with the technical findings of Allied investigators in Germany and occupied Europe since the war.

The current volume lists reports in thirty-three major categories and some eighty additional subcategories. Reports with broad importance are listed under more than one category.

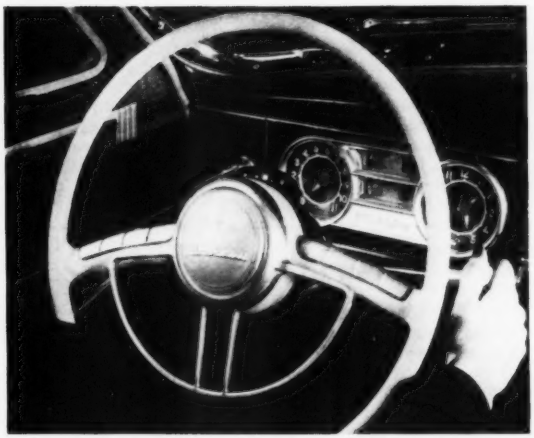
Combined Intelligence Objectives Subcommittee, B.I.O.S., F.I.A.T. and other declassified European technical reports are available to the public from the Office of Technical Services. PB 96941, J.I.O.A. Subject Index: C.I.O.S. Volume I, 270 pages, sells for $3.00 per copy. Orders should be addressed to the Office of Technical Services, Department of Commerce, Washington 25, D. C., and should be accompanied by check or money order made payable to the Treasurer of the United States.



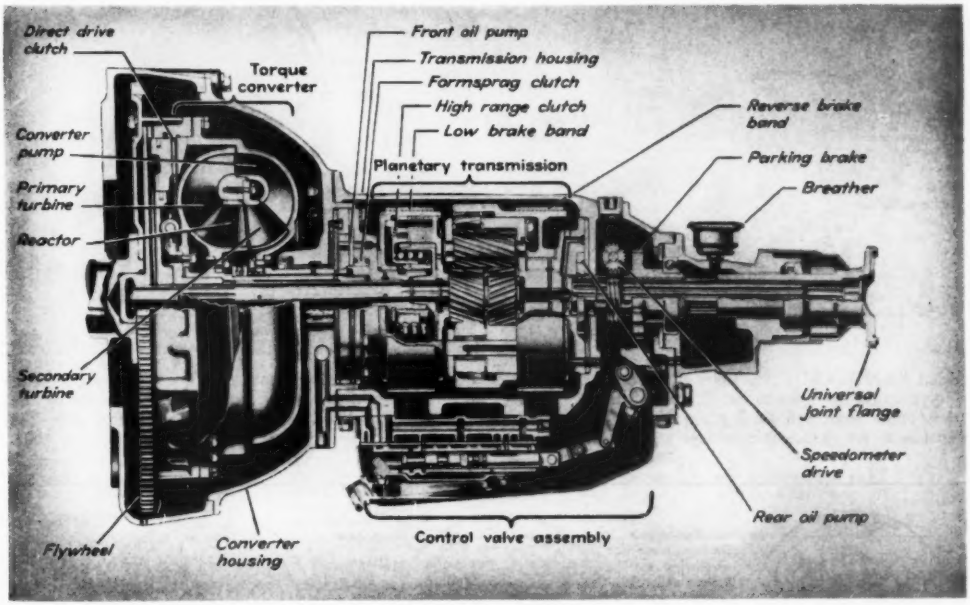
PACKARD TRANSMISSION has two clutches—one forward and the other to the rear of the torque converter. The high range clutch connects the converter directly to the drive shaft. This clutch bypasses all gearing so that converter alone must provide the multiplication of engine torque needed to start and accelerate the car. The direct drive clutch is located between the engine and the torque converter turbine. Car speed and throttle position control the engagement of the direct drive clutch, which rigidly connects engine to rear wheels and allows converter to "float".

Packard's Ultramatic Drive

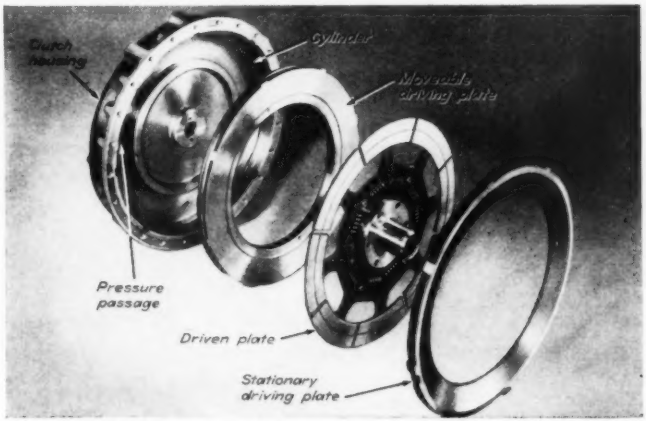
The torque converter in Packard's automatic transmission is intended only for acceleration. At cruising speeds, a direct-drive clutch completes a mechanical connection between engine and rear wheels. This renders the torque converter inoperative, preventing wasteful slip and oil churning after the coupling point is reached. The driver's control of the direct drive clutch is similar to his control of the fourth speed in overdrive cars. At speeds between 15 and 56 mph, a momentary release of the gas pedal causes the direct drive clutch to engage. Within this same range of speeds, the driver can disengage this clutch and return to converter operation by pushing the pedal to the floor. Above 56 mph, the direct drive clutch is engaged regardless of throttle setting. During deceleration, the car stays in direct drive until speed drops to 13 mph. Thus, the engine aids braking.



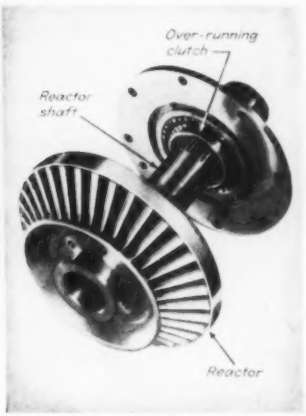
LIGHTED LAMP behind the sector letters tells driver what position the controls are in. Cars with Ultramatic have no clutch pedal or gear shift lever. Engagement of the direct-drive clutch depends on throttle opening and car speed. For every throttle position there is a definite speed at which clutch operates automatically—unless the driver chooses to exercise his control over clutch before that point is reached.



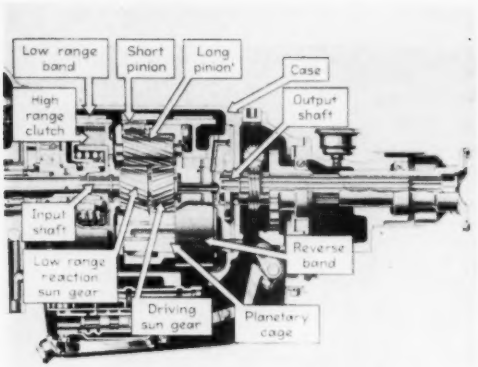
TO SIMPLIFY CONSTRUCTION, the rotor units are flanged and bolted to hubs which engage with quill shafts. These quill shafts extend back to the planetary transmission. The converter pump rotor is attached to a quill shaft that acts as a seal and outboard bearing for the unit. This shaft also drives the front oil supply pump. A second quill shaft inside the first carries the reactor and extends through the pump to an overunning clutch. The direct drive clutch disk and the turbine are both fixed to the hub which is splined to the transmission input shaft.

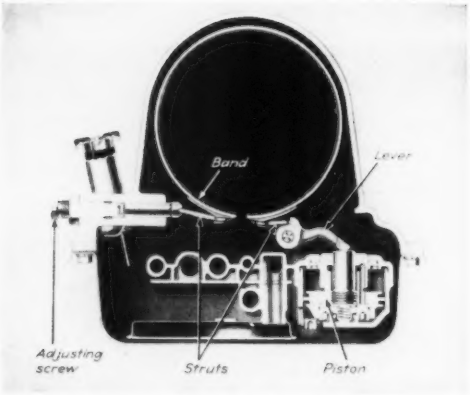


HOUSING of direct clutch rotates with the flywheel. For engagement, oil passes through hollow transmission input shaft, then through radial pressure passage into clutch cylinder. The oil shifts the moveable driving plate, forcing the driven plate against the stationary driving plate. Then, engine torque is transmitted directly to the driven plate which is splined to the input shaft.



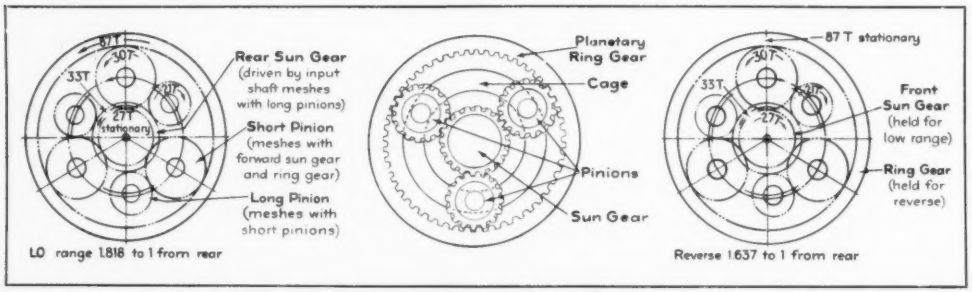
MORSE-FORMSPRAG overrunning clutch holds reactor stationary at low speeds, allows it to turn with turbine and pump after coupling point is reached. (*continued on next page*)



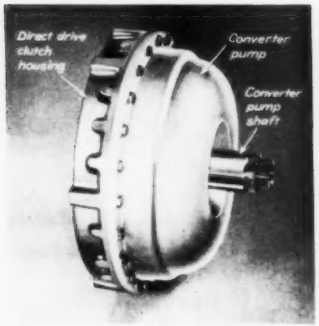


HIGH RANGE CLUTCH, when engaged, locks the low range reaction sun gear to the clutch hub that is splined to the input shaft and driving sun gear. This locks the planetary system which then rotates with the input shaft.

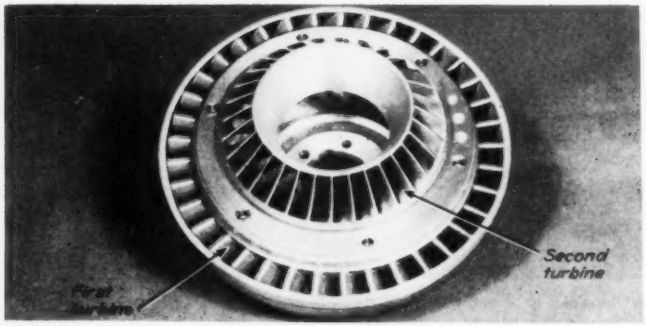
LOW RANGE BAND holds the low range reaction sun gear when gear reduction is required. One end of the band is held in position by an adjustable strut while the other end is operated by the piston of the hydraulic unit.



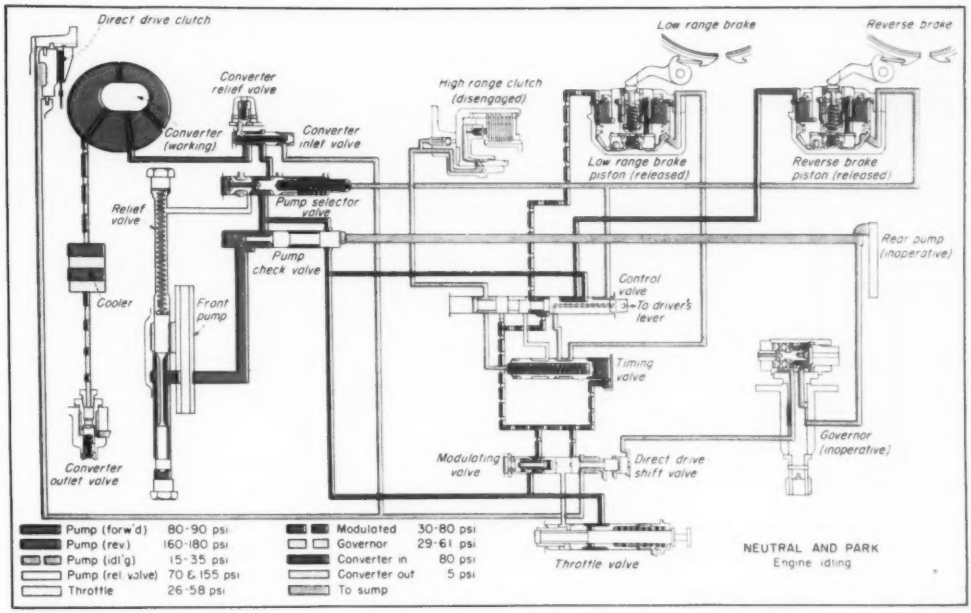
WHEN REAR SUN GEAR is rotating and the pinion cage is stationary, the long pinions turn counterclockwise and the short pinions clockwise. If the forward sun gear is held, the short pinions will walk the planetary cage around clockwise at a reduced speed. Releasing the forward sun gear and holding the ring gear causes short pinions to walk the cage counterclockwise inside the ring gear, giving reverse at a reduced speed.



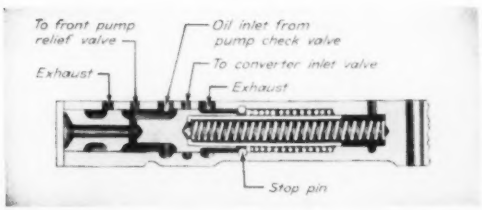
DIRECT DRIVE clutch housing and converter pump are assembled as a unit and bolted to flywheel.



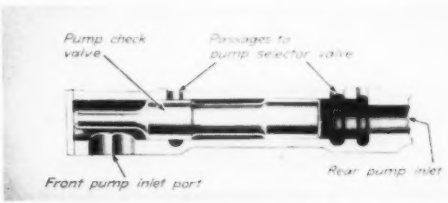
TURBINES, converter pump and reactor are mainly sand cast from aluminum. This represents a considerable cost saving over entirely plaster cast units. The finish of the sand castings is smooth enough for efficient performance.



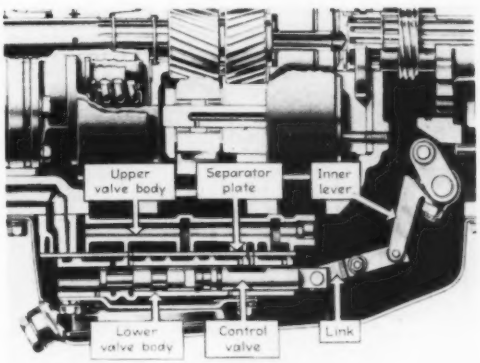
IN NEUTRAL AND PARK the front pump alone is operating. The pump output is maintained at 85 psi by the pressure relief valve. The selector valve bleeds back 70 psi of the pump output pressure to the relief valve where it combines with the spring load to give a back pressure of 85 psi on the relief valve piston. The pump output is supplied to the converter; to the reverse brake piston through the driver's control valve, and to the low range brake piston through the modulating valve and driver's control valve. The pressure on the topsides of the brake pistons maintains positive release of the brake bands. With the driver's control lever in the park position, a pawl engages a gear that is splined on the output shaft, preventing rotation of the drive shaft and rear wheels.



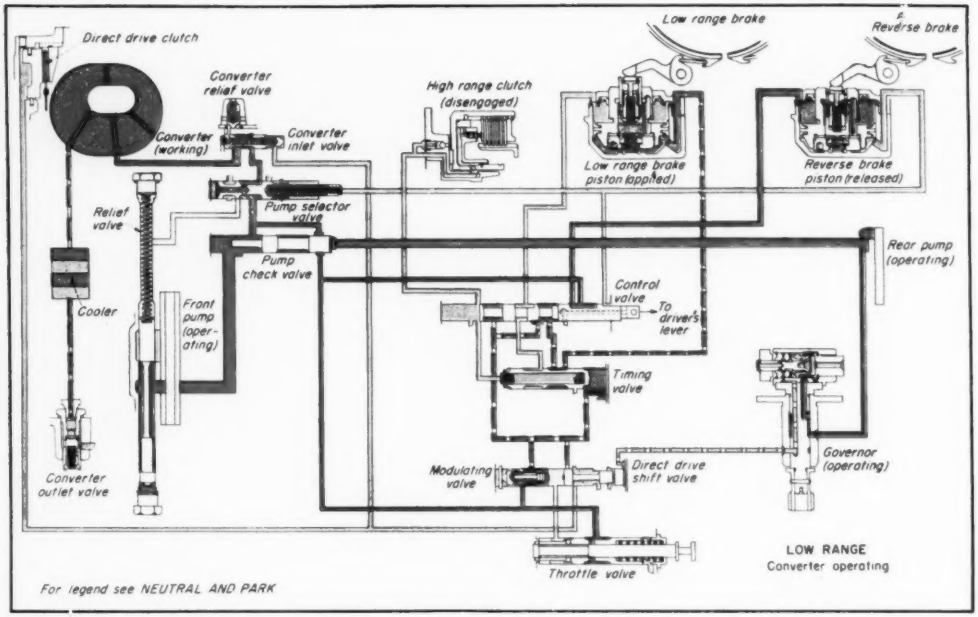
PUMP SELECTOR VALVE regulates the maximum pressure output of both front and rear oil supply pumps.



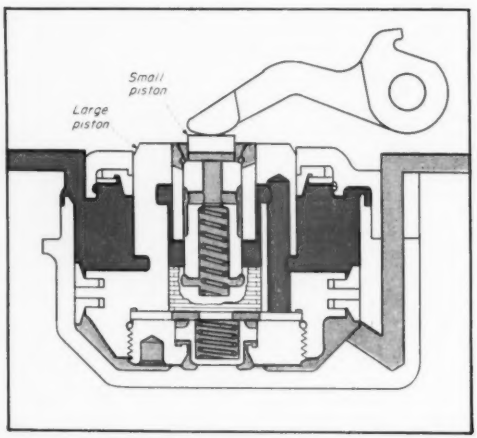
PUMP CHECK VALVE operates to permit the rear pump to supply the hydraulic circuit when its output pressure exceeds that of the front pump.



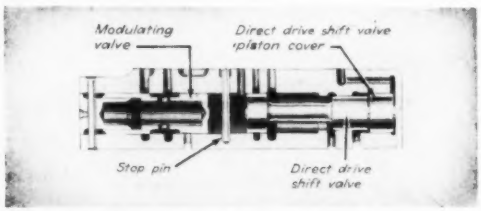
ALL VALVES of the hydraulic circuit are located in the oil sump below the transmission. For economy, the nine valve bodies are not fabricated separately but have been combined into two aluminum castings. The upper casting or body contains the pump check, pump selector, converter inlet and converter relief valves. The lower casting contains the control, throttle, modulating, direct drive shift and timing valves. (*continued on next page*)



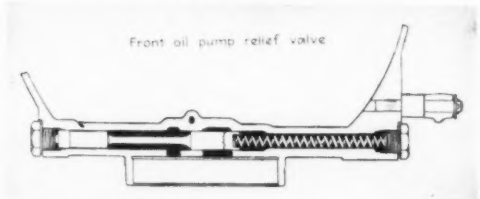
WHEN SHIFTED to the low range position, control valve cuts off the modulated pressure from the spring loaded end of timing valve. The modulated pressure at the rear end of the timing valve moves piston forward. This directs pressure to the apply-side of the low range piston, thereby operating low range brake. Power is delivered to rear wheels through converter and low range gears. With car movement, rear pump delivers pressure to the governor and the pump check valve. The governor meters pressure to the direct drive shift valve in proportion to car speed. Should driver continue in the low range above 15 mph, the governor pressure will rise sufficiently to move piston of direct drive shift valve to the left. This permits modulated pressure to engage direct drive clutch.



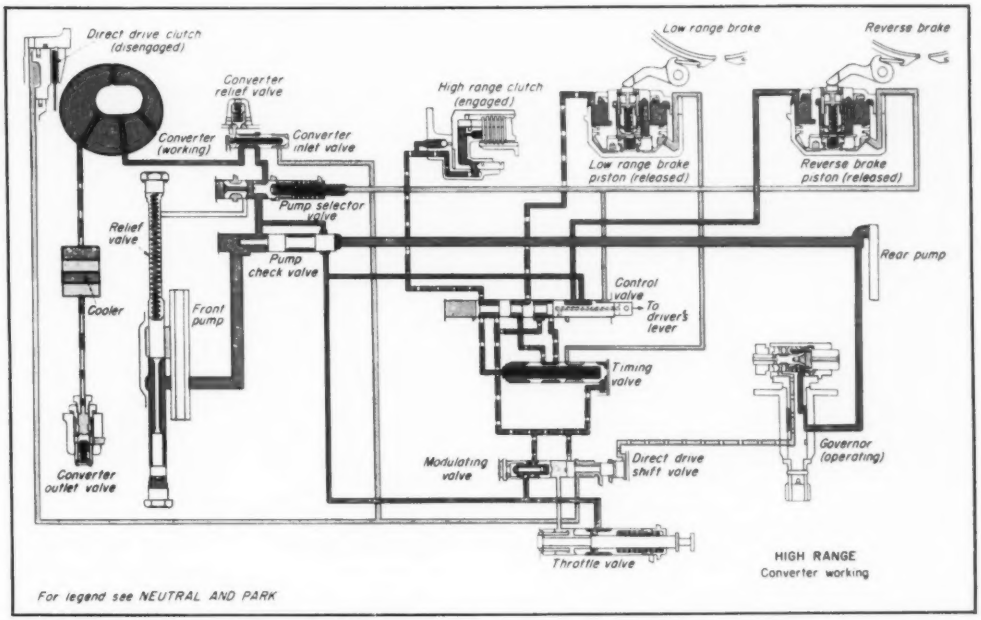
OIL PRESSURE holds brake unit released. To apply band, oil enters center cylinder via check valve at bottom. Small piston takes up clearance and vents "release" oil via an internal port. Large piston then rises, closing check valve and actuating brake through trapped oil and small piston.



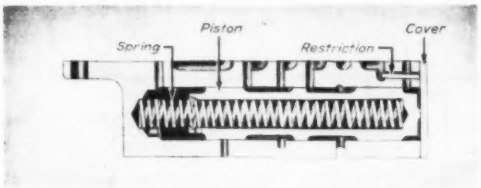
PRESSURE MODULATING VALVE provides a varying pressure for smooth engagement of clutches and brakes.



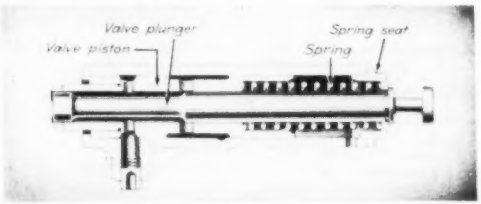
FRONT OIL PUMP relief valve regulates the front pump oil pressure. This pressure is maintained at 170 psi for reverse and 85 psi for other positions.



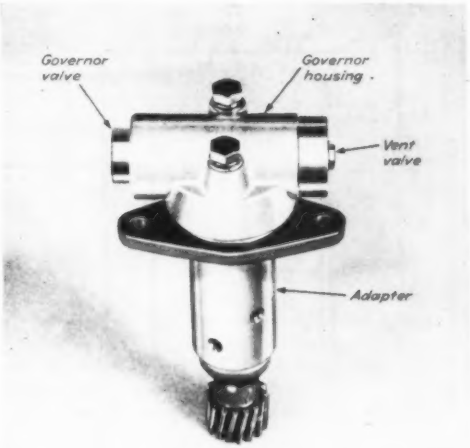
WHEN CONTROL VALVE is shifted to the high range position, the varying pressure from the modulating valve is directed to the high range clutch cylinder and to the spring loaded side of the timing valve. The movement of the valve to the right is retarded by the slow discharge of oil through orifice in the rear end of the valve. This movement simultaneously applies release pressure to the topside of the low range brake piston and vents the apply-side of the piston. This retards low range release and provides an overlapping high range clutch engagement and low range brake release. Thus, engine runaway is prevented when shifting from low to high range. The throttle position determines the magnitudes of pressures in the modulated lines.



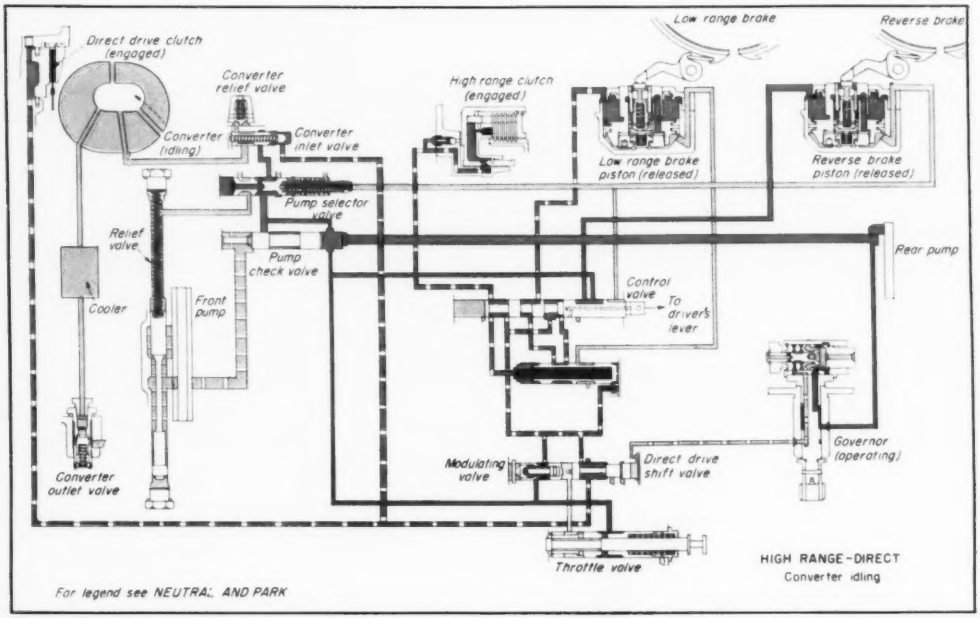
TIMING VALVE synchronizes the engagement and disengagement of the high range clutch and low range band.



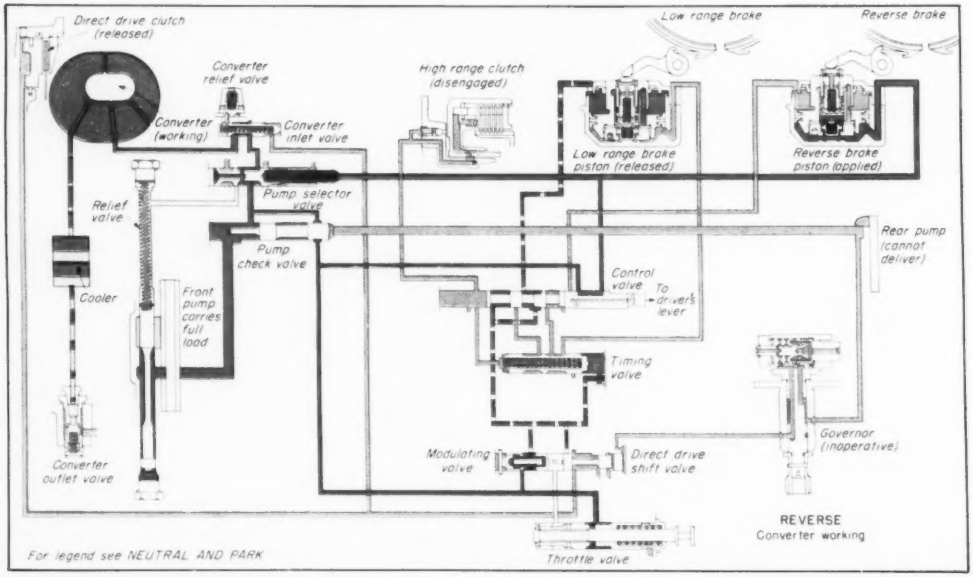
THROTTLE VALVE provides pressure to the direct drive shift valve in proportion to throttle opening. This pressure reacts with the governor output pressure.



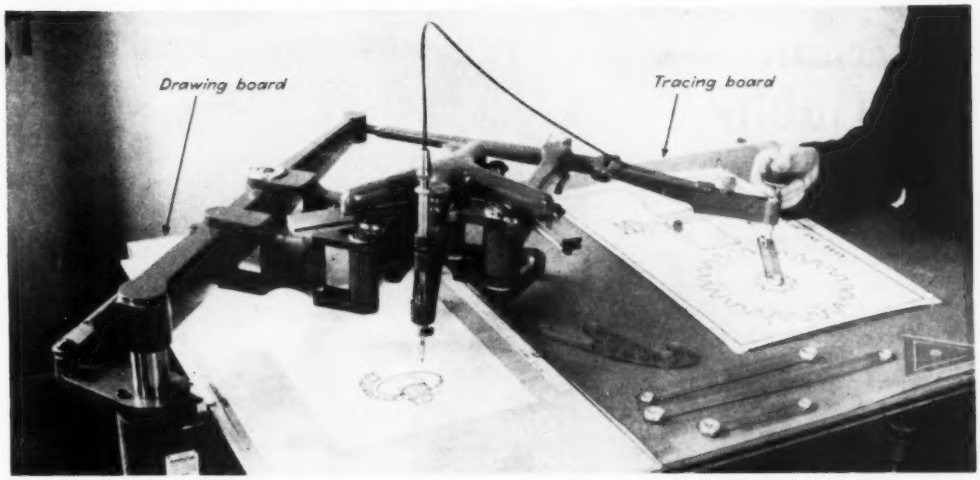
HYDRAULIC GOVERNOR is a centrifugal hydraulic device which delivers oil pressure proportional to car speed to the direct drive clutch shift valve.



AS CAR ACCELERATES, pressure from governor rises until it moves direct drive shift valve against throttle valve pressure. This admits pressure to direct drive clutch and converter inlet valve, operating clutch and stopping flow of oil to converter. When rear pump pressure exceeds front, check valve isolates front pump.



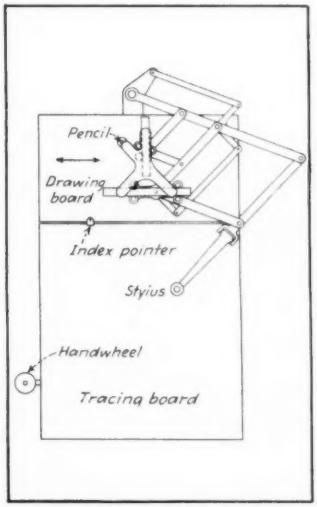
IN THE REVERSE POSITION, the control valve directs oil pressure to the spring-loaded end of the pump selector valve. This pressure added to the spring load increases the regulated pump pressure to 160-180 psi. This higher pressure holds reverse brake band against the ring gear torque which is greater than that of the sun gear.



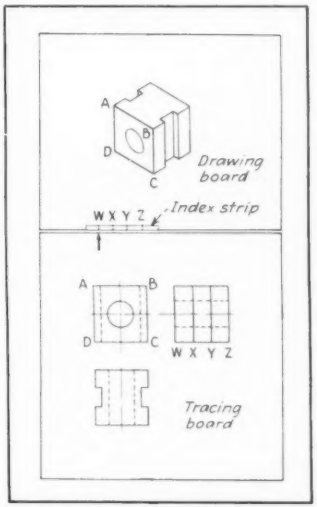
TWO TABLES are provided with the machine. One is under the tracing point and the other under the drawing point. The drawing table is mounted on a slide and can be traversed in relation to the fixed tracing table. A handwheel and cable system control the position of the drawing table. Drawing point is raised and lowered through a flexible shaft leading to a thumb button over the tracing point. Light alloy castings are used to reduce inertia. Conventional methods of producing isometric projections call for a skilled draftsman and much plotting of coordinates.

Split Table Adds Third Dimension To Tracings

The Perspector drafting machine automatically rotates and foreshortens lines traced by its stylus. This feature which is accomplished by a compound pantograph link system enables the machine to convert standard engineering drawings into isometric projections. The drafting table used with the machine is split into two separate sections. Thus, the drawing board can be moved in relation to the tracing board to give depth to the views. The new machine simplifies the procedure and reduces preparation time. Omerex Precision Products Corp., N. Y. C., distributes the machine for the manufacturer, Isometric Projections, Ltd.



COMPOUND PANTOGRAPH link system is arranged to give a greater reduction in one direction than in the direction at right angles to it. The proportion is such that a circle scribed by the tracing point is converted by the drawing point into an ellipse. The minor axis of the isometric ellipse is 0.577 of the major axis which remains actual size. Stylus is guided by radius arms, curves and triangles.

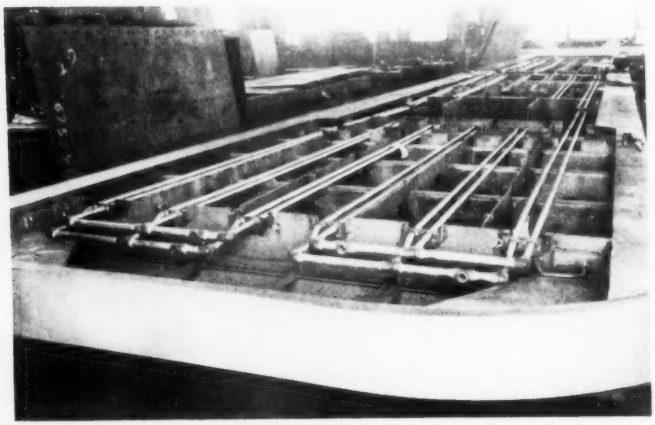


INDEX STRIP is prepared from the plan view of the orthographic drawing. The strip shows the isometric distance between each plane of the object where there is a change in section. Operator progressively shifts the drawing board to each point marked on the strip. At each station, he uses the front elevation as a template from which to trace the contours that will be visible in the projected view.

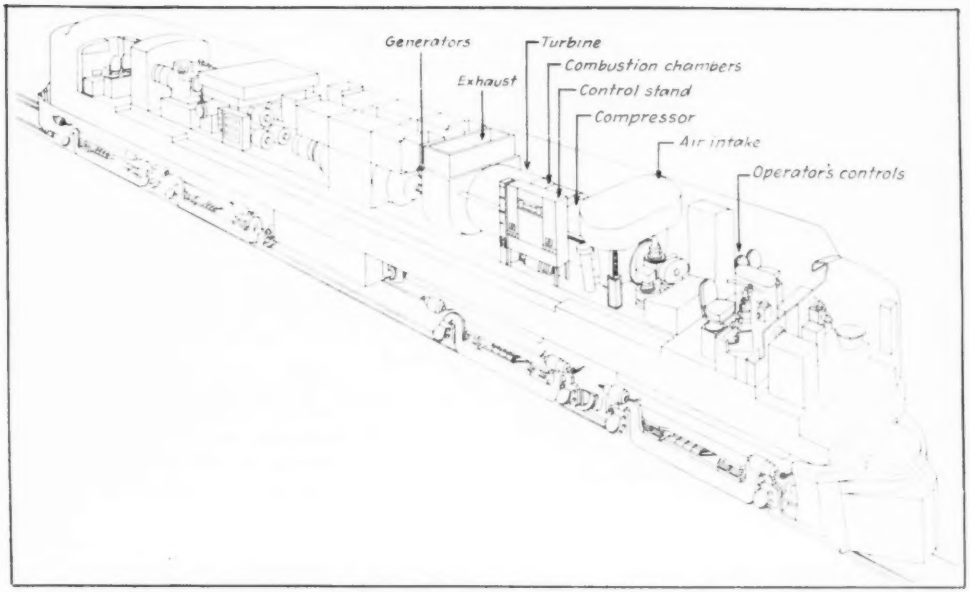
American Gas Turbine Locomotive

A 4,800 hp gas turbine powers the new freight locomotive developed jointly by the American Locomotive Co. and the General Electric Company. This is the first gas turbine-electric locomotive built in the United States. Principal assets of the gas turbine plant is light weight, compactness and ability to burn low grade fuels. Because of space and weight savings, locomotive can store its own fuel supplies. The manufacturers will use performance data of the locomotive as the basis for continued research. Problems for study include thermal efficiency (about 17 percent at full load compared with 34 percent for diesel-electrics) and influence of altitude and ambient temperatures on operation.

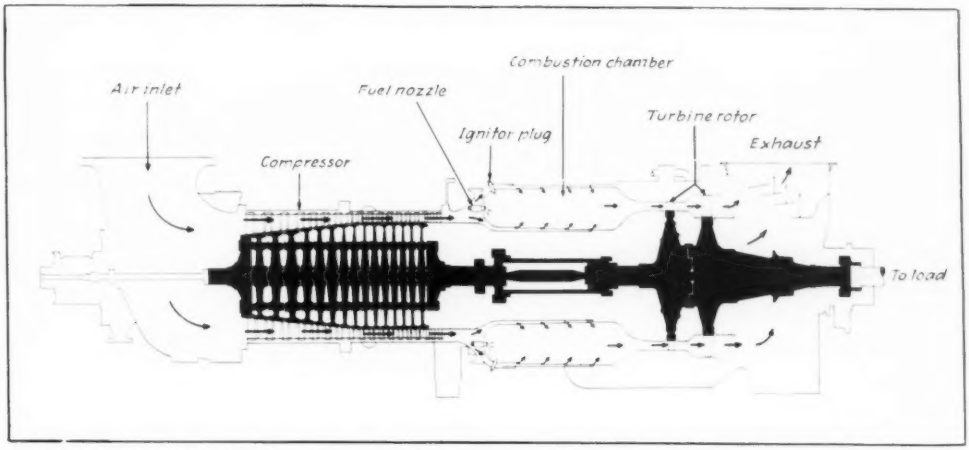
AIR FILTERS line both sides of the locomotive. The tremendous volume of inlet air required for gas turbine operation makes this large filtering area necessary. At full load, air enters locomotive at rate of 80,000 cfm. After compression and heating, air exhausts through roof duct measuring approximately 2 x 6 ft. The high velocity of the exhaust air causes a roaring noise which designers have not muffled up to the present.



FUEL TANKS occupy entire undersection of the locomotive. Tanks are extensively baffled to minimize shifting of the fuel on curves and during sharp braking. Running along the length of the tanks are the steam pipes for heating the fuel. The Bunker "C" fuel used is a high viscosity oil and must be kept at temperatures between 90 and 100 F in order to flow through feed lines. Storage capacity is 6,700 gal which is sufficient for a twelve hour haul. The sketch at right above is a cross-section of the superstructure framework. Since major portions of locomotive's sides are open and do not contribute to structural strength, heavy frame is needed. Frame is built on the deep channels, which form sides of the fuel tanks. Cross-members support turbine and other heavy apparatus to lighten floor loads on the tank covers. The Union Pacific RR will operate the locomotive for the manufacturers.



LIGHTER WEIGHT per horsepower of output is feature of the new locomotive. The 500,000 lb locomotive rides on four two-axle trucks. This is one truck less than is needed for a diesel-electric locomotive of equivalent output. Each axle is mounted on roller bearings and carries a 600 hp d-c traction motor. The locomotive has self-contained storage facilities for Bunker "C" and diesel fuels, lubricating oil, water and sand. No tender is used. Diesel oil is needed for the starting engine and for the boiler supplying steam to heat the Bunker "C" fuel oil. Components of the electric drive system are similar to those in diesel powered locomotives.



IN-LINE ARRANGEMENT of compressor, combustion chambers and turbine results in great simplicity while minimizing pressure losses. No regenerator or other auxiliaries are used to elaborate the cycle. The increase in efficiency that would be gained thereby was not justifiable when the added space, weight and cost involved were considered. An internal shaft from the turbine wheels drives the 15-stage compressor rotor which consists of separate wheels bolted together. The wheels of the first six stages are of aluminum alloy, while steel wheels are used in the higher pressure zones. The six combustion chambers consist of a carbon steel outer casting with a stainless steel inner liner. Turbine output shaft operates at 6,700 rpm which is geared down to feed generators.

Analyzing a Product For Production

One of the major steps in the development of a new product or the redesign of an old one is the modification of the design to make it suitable for production.

The considerations that might enter into the selection of the fabricating method to be used are too numerous for generalizations, but the designer must consider the proposed process from three standpoints: (1) The adaptability of the product to the proposed method of production; (2) the practicability of the proposed method, based on the availability of materials, labor, and equipment; and (3) the estimated unit cost of the product if made by the proposed method.

To the experienced designer, the shape of the part and the specifications to which it must be produced will immediately suggest several methods of manufacture. Those same factors will also make impractical the use of other methods. But the line between proposed methods may be very fine, and if so, a comprehensive analysis of production methods should be made to insure that the highest quality part is obtained at the lowest cost. The accompanying chart lists some of the factors to be considered in such an analysis. Others may be added when required.

DESIGN ANALYSIS

1—Can a part of this shape be produced by the proposed method?
2—Can a part of this size be produced by the proposed method?
3—Can the material of which the part is to be made be worked by the proposed method?
4—Can the weight of the part be held within satisfactory limits?
5—Can the required appearance and finish be obtained?
6—Are major design modifications necessary?
7—Is design simplification possible?
8—Can model changeovers be quickly and economically made?
9—Will dimensional stability of the part be satisfactory?
10—Can the required tolerances be held?
11—Will strength and other mechanical properties be satisfactory?
12—Will the physical properties meet specifications?
13—Can special features be obtained?
  (A) Case-hardening
  (B) Resistance to fluid leakage
  (C) Resistance to high or low temperatures
14—Can inventory be reduced?

PRODUCTION ANALYSIS

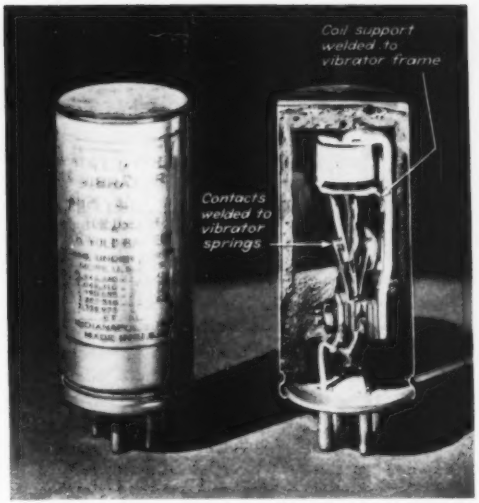
1—Can estimated production rate be obtained by the proposed method?
2—Can more than one part be produced simultaneously?
3—Can different parts be produced simultaneously?
4—Can prior operations be reduced?
5—Can subsequent operations be reduced?
6—Can simultaneous operations be performed?
7—Can assembly be facilitated?
8—Can handling be reduced?
9—Is the material available?
10—Will new production equipment be required?
11—Will new production facilities be required?
12—Is labor available for production?
13—Are tools available or must they be obtained?
14—Can the part be put into production within reasonable time limits?

COST ANALYSIS

1—Initial cost of equipment
2—Initial cost of tooling
3—Amortization period for equipment
4—Amortization period for tooling
5—Estimated amortization cost of equipment/unit time period
6—Estimated amortization cost of tooling/unit time
7—Estimated cost of maintaining equipment/unit time period
8—Estimated cost of maintaining tooling/unit time period
9—Estimated direct labor cost/unit time period
10—Estimated indirect cost/unit time period (engineering, supervision, general overload)
11—Estimated cost of services—unit time period (gas, water, power)
12—Total of items 5 to 11 inclusive
13—Estimated cost of material per piece
14—Total estimated production cost, per piece, based on estimated production rate.

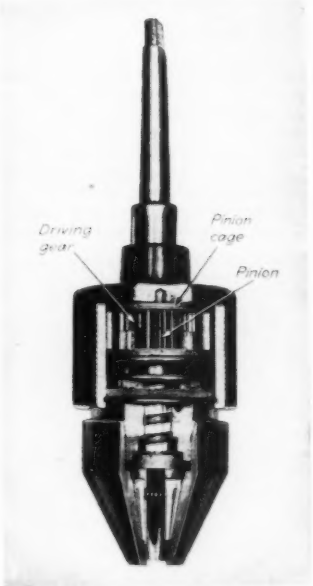
Welding Dissimilar Metals

Joining of dissimilar metals such as the alloys of steel, copper, nickel, aluminum, magnesium, as well as molybdenum, tungsten, tantalum and Invar is done extensively by resistance welding in the electrical manufacturing industry. P. R. Mallory & Co., Inc. uses resistance welding exclusively for joining tungsten contact disks to steel vibrator springs of their vibrators. In the typical Mallory vibrator assembly shown here, the 0.022 in. thick tungsten disks, 0.125 in. in diameter, are resistance welded to the 0.008 in. thick spring steel. The contact disk is copper coated on the joining side prior to welding. This design assures good electrical conductivity and long service life of the unit and permits one operator to produce as many as 460 welds per hour. This rate would not be possible with any other method of assembly.



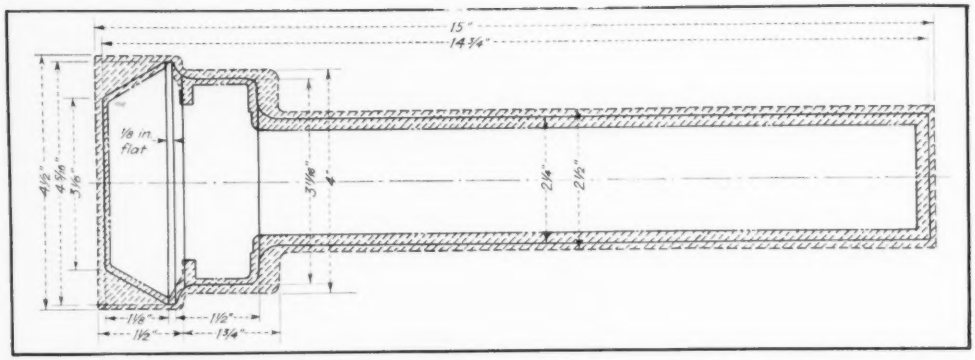
Chuck Pinions Sliced from Cold Drawn Stock

Sections of pinion rod were substituted for machine cut pinions in the Wahlstrom automatic drill chuck. The American Machine and Foundry Company of Brooklyn, N. Y., manufacturer of the chuck, reports that the substituiton resulted in a cost saving of 48 cents per set of three pinions to each chuck. The pinion rod is produced by a cold drawing operation. Within certain size limitations, rod can be made with any desired cross-section contour.



THREE PINIONS mounted in cage around driving gear convey spindle torque to operating mechanism of the automatic chuck. Operator can change tools without stopping drill motor.

CHUCK MANUFACTURER has only to cut cold drawn stock into required lengths and drill holes for shafts. Pinions are then ready for assembly. The completed pinions retain the uniformly hard and smooth surface produced on the bar during cold working. The Rathbone Corporation of Palmer, Mass. supplies the cold drawn stock from which these pinions are cut.

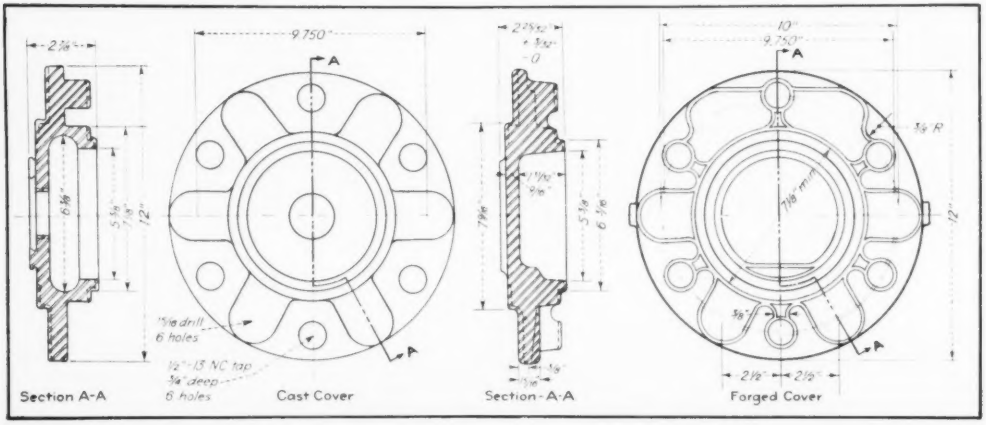


To Die Forgings For Lower Costs

One of the upset die and drop forged parts described here was formerly a steel casting and one was a flat die forging. They were converted to die forgings by leading manufacturers of drop and upset forgings, either to improve part strength or to decrease part cost—or both. In many instances, a portion of the cost reduction was due to a decrease in machining time, which was brought about by better machinability and by less surplus stock on the forgings, as well as absence of porosity, blow holes and sand pits in the parts. The parts shown on this page are fabricated by a large forging concern.

DOTTED LINE shows the outline of a conveyor shaft as made by hammer die forging, and solid line, the same shaft made by upset die forging. When hammer die forged, the part was made from 4½ in. dia. hot rolled steel that was drawn down on a blacksmith hammer. With this method, a considerable amount of surplus stock was left on both the head and the stem, as shown by the cross sectioning between this contour and the profile of the finished part. By hot upsetting the end of 2¼ in. dia stock, a much closer contour was obtained, considerable material was saved, and a better grain structure was obtained on the head, which was important inasmuch s this end is cut into gear. The savings in piece price on the first order of 200 pieces paid for the dies, and in addition there was a large saving in machining time.

COMPARISON between cast and drop forged cover plate. While it was necessary to increase weight of the rough part due to draft on the forging, as compared with an undercut core on the casting, elsewhere on the part closer tolerances were held, price was lower, and quality of machining was improved to such an extent that the overall saving resulting from the use of the forging was sufficient to warrant the change. The fact that two additional machining operations were necessary on this part over those required for the casting is an interesting point inasmuch as the overall cost of the forging was lower even with these added operations.

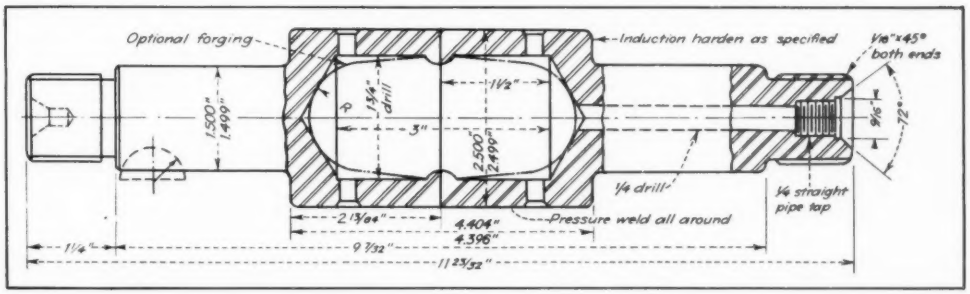


Pressure Welding Speeds Production Of Tractor Parts

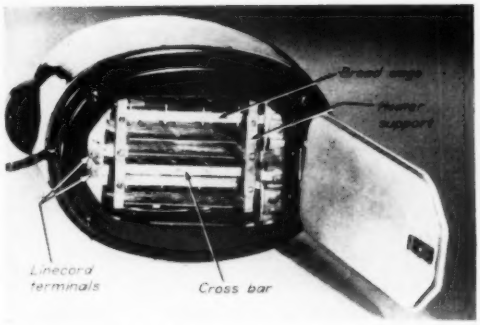
Two changes were made by engineers at the Tractor Division of the International Harvester Company to reduce the cost on the Front Idler and Track Roller Shafts, of which ten are used per tractor. First, pressure welding was specified instead of arc welding. The immediate effect of this change was a faster rate of production, plus a weld which leaves no flash—only a smooth upset portion. The two halves are loaded in a fixture and locked in place. The parts are heated to welding temperature by acetylene rotating head and pressure is appllied with hydraulic cylinder at the proper time to affect pressure weld.

The second change in the part was the use of 1043 or 1045 carbon steel instead of 1015. This made it possible to induction harden the surface instead of carburizing it, as formerly. Not only is induction heating faster but distortion is minimized so that a machining operation that was necessary after carburizing is no longer required.

The net result of these changes was a reduction in part cost, as was anticipated. However, because of the fewer operations needed to finish the part and the faster rate of production, inventory on this item has been cut approximately in half. Another and equally important result was that the strength of the part in the weld was increased from an average of 74,000 psi to 140,000 psi —almost double the former value.



Simplified Toaster Assembly



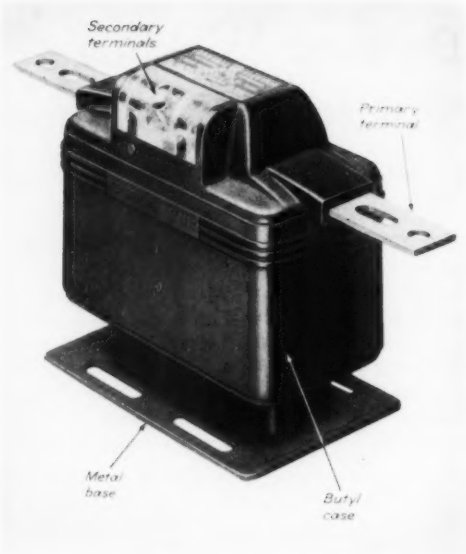
SIX SCREWS hold the heaters of this Westinghouse automatic toaster in place. The same screws also make the electrical connections between the heater wires and the current-carrying heater supports. These supports and rigid crossbar complete the electrical circuit. No flexible wiring or soldered joints are involved.

Westinghouse Electric Corp.

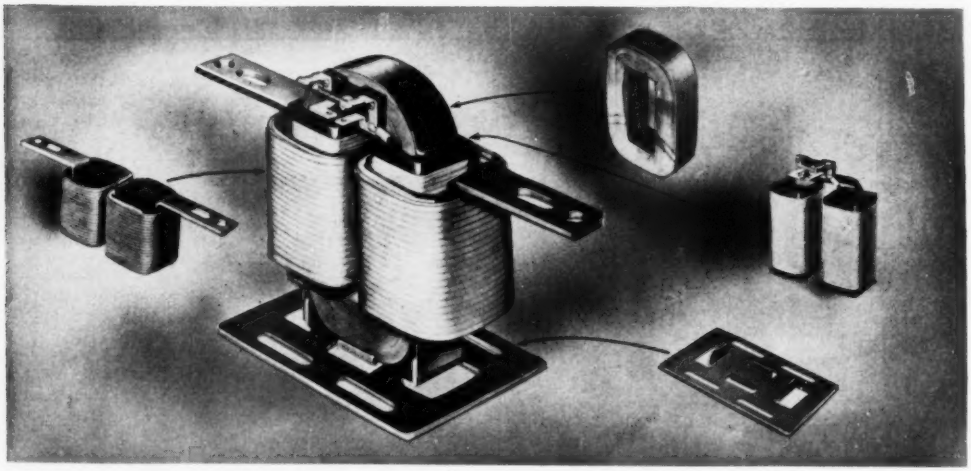
ALL FOUR HEATERS can be removed through the crumb tray opening. Either side heater can be freed singly by taking out two screws. It is now possible to service the toaster without disturbing the casing. Prior designs required complete dismantling of the casing to replace a heater. This design reduces toaster assembly time.

Butyl Molding Houses and Insulates Transformer

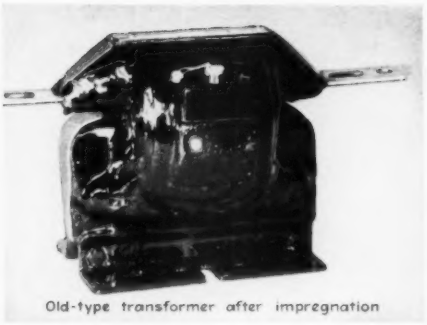
The exterior casing and the coil insulation of this new instrument transformer are molded as a single structure. Developed by the General Electric Company, the new process eliminates several operations in transformer manufacture. The laborious hand wrapping and impregnation of the coils is no longer required. The assembled coils and core are simply placed in a mold which is then filled with compound. Principal ingredient in the molding compound is butyl, a synthetic elastomer derived from petroleum. The butyl is flexible enough to withstand extreme dimensional changes in the metal parts caused by overload. It can be molded under pressure into a dense, homogeneous insulating mass having no voids. The dielectric strength of butyl is almost double that of the asphalt impregnated paper formerly used. In addition to its greater adaptability to mass production, the butyl-molded transformer is stronger since the one piece construction holds all parts firmly in position. The new transformers will be made in ratings from 10 to 800 amp for 5,000 volt service.



BUTYL COMPOUND that is molded around the core and coils also forms the transformer case. The nameplate data and polarity markings are molded directly into the surface. After the molding operation, it is necessary only to remove the flash, color the nameplate and attach the hardware and cover for the secondary terminals.

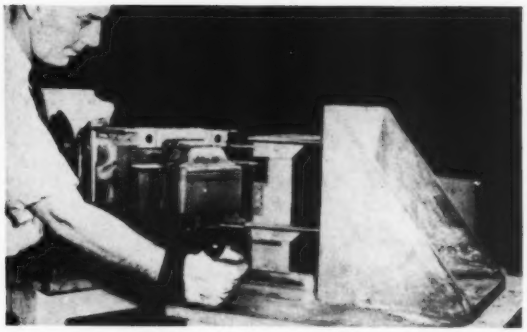


COILS are not wrapped before molding. The wrappings visible in above picture are between-winding coverings which are placed on copper before it is formed into coils. The "figure-eight" primary winding encloses the secondary coils, which are mounted on the legs of the core. Formerly, primary and secondary windings were single coils, placed one outside the other. With the new construction, heat is distributed over a wider area resulting in better dissipation. Also, the two-section windings increase the mechanical strength of the transformer. Large forces developed in the windings by momentary overloads of a high value are divided between the two parts of the coils. The transformer has the electrical and mechanical ability to withstand instantaneous overloads 180 times rated capacity.



Old-type transformer after impregnation

PREVIOUS PRACTICE was to wind a fibrous material around the coils and then impregnate the whole with asphalt or similar insulating compound. In some designs, 1,000 ft or more of crepe paper were required for proper insulation. Most wrapping was done by hand because of complex configuration of the coils. After impregnation, coils were positioned in a transformer case, then covered with asphalt.



IN THE MOLDING OPERATION, the assembled core and windings are placed in a hot cast iron mold. Butyl is injected into the mold under controlled pressure and temperature conditions. After butyl compound has been allowed to set and cure, operator removes the completed transformer from the mold. The new transformer meets the same EEI standards as regards dimensions and is approximately the same weight as previous designs. Butyl is resilient and highly resistant to moisture.

Largest Plastic Molding Cuts Television Cost

ONE-PIECE MOLDING of phenolic plastic houses chassis of this television set by Admiral Corp., Chicago. This model features a 10 in. picture tube with 61 sq in. of viewing area. Console measures $32\frac{1}{8}$ x $16\frac{3}{8}$ x $17\frac{1}{4}$ in. and is made molded by Molded Products Corp., Chicago.

TWO MEN OPERATE the 2,000 ton press, which can produce one cabinet every six min. Molding weighs 35 lb as it comes from the press. Wood cabinets previously used were made on a production line that required the services of several dozen operators. Substitution of plastic for the wood cabinet permitted a reduction of $50 in the set's selling price.

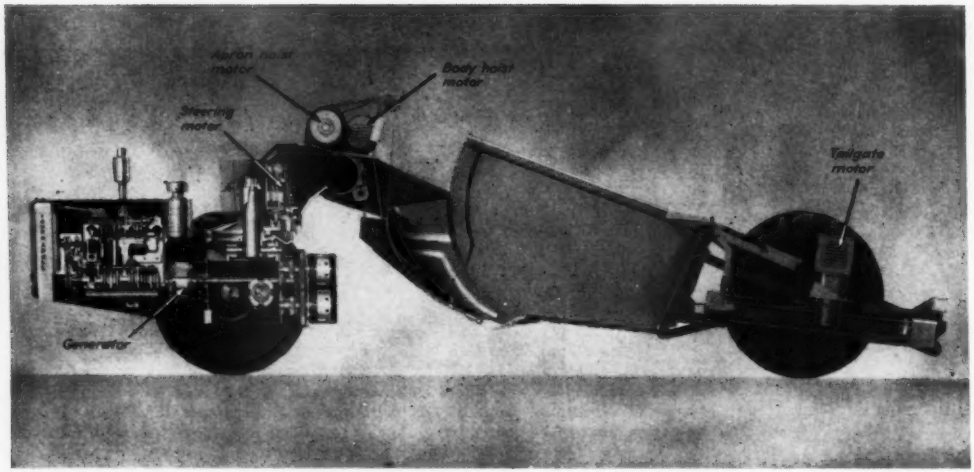


Fig 1—Main elements of the electrical system on a 55 ton carryall. The generator is directly connected to the engine drive shaft. There is practically no limitation on the sizes of the driving motors, provided there is sufficient generator power available.

High Starting Torque Electrical System for Auxiliary Drives

An a-c electrical system for earthmoving equipment that utilizes a squirrel cage induction motor with the cooling fan in the rotor circuit. System development, performance characteristics, comparison with conventional drives, and industrial applications

R. G. LeTOURNEAU
R. G. LeTourneau, Inc.

AUXILIARY POWER SYSTEMS of conventional design are becoming inadequate for modern earthmoving equipment, primarily because speed and horsepower requirements are greater than can be obtained from them. Up to 50 hp may be necessary to operate some auxiliary mechanisms at sufficient speeds to coordinate with the movements of the vehicle.

Mechanical systems of this capacity are bulky, difficult to maintain and operate, and require an additional power take-off, including clutches and brakes, for each independent movement. Hydraulic systems are limited in output by the flexibility necessary in the hoses that connect moving elements. Pneumatic systems have the same disadvantages as do hydraulic.

The only alternative, an electrical system, overcomes most of these difficulties. As shown in Fig. 1, it can be broken down into any number of motor components operating from the same generator, the only connecting elements being flexible wires; and there is no practical limitation on either generator or individual motor capacity. The problem is to obtain a light weight system that requires little maintenance and has the necessary pull-out torque. The obvious questions are: Shall the system be a-c or d-c? If a-c, what frequency shall be specific? What type of motor and generator will give the best overall operating characteristics?

The Electrical System

The most important decision to be made is whether to use alternating or direct current. Most auxiliaries on earthmoving machinery are heavy, and are started from a standstill position, as, for example, the blade of a bulldozer or the bowl or apron of a scraper. One scraper model is unloaded in about 16 sec, and the torque, required during the cycle, is as follows, based on four ampere readings at equal time intervals:

Amperes	Torque, ft-lb
240	135
120	100
160	95
100	75

Consequently, the driving motor must have a high starting torque to overcome inertia and initial friction.

Direct current motors would meet operating requirements. However, maintenance of commutators and brushes is difficult under field conditions, especially when experienced electricians are not available and when equipment is exposed to severe atmospheric conditions. After considerable study, alternating current was selected because of the well known reliability of a-c induction motors and because generators could be constructed as rotating field machines, which would relieve slip rings from carrying heavy line currents. Solenoid and relay coils are also more compact when designed for alternating current.

Operation on a frequency of 60 cycles would have been in line with

standard electrical practice, but weight and size were at a premium, and a higher frequency, with a consequent increase in motor speed, would decrease motor size and weight while maintaining a high horsepower output. On the other hand, higher frequencies increase the number of generator poles for a given speed. Since it was desirable for mechanical reasons to couple the generator directly to the 1800 rpm vehicle engine, a frequency of 120 cycles was selected as offering a good compromise. With this frequency, an eight pole generator could be used, as compared with a 16-pole unit for 240 cycles.

The next problem in selecting the characteristics of the electrical system was to determine the type of circuit and the operating voltage. Three-phase operation was selected because it permits greater economies in the generator and motor design, and because induction motors, which appeared to be the most suitable types, could be made self-starting. An additional advantage of three-phase systems is the uniform holding force exerted by three phase magnets; this is an important consideration since electromagnetic brakes often must be provided to prevent over-travel of motor shafts.

Finally, a no-load voltage of 240 volts was selected to minimize conductor size without requiring excessive insulation or unusual safety precautions.

Electric Motor Design

One of the principal requirements for the motor was that it be able to develop a high starting torque. Constant operating speed was not of primary importance. Single-phase series motors were rejected because frequently auxiliaries are operated by wire ropes; in the event of rope breakage, a series motor would attain dangerously high speeds. In addition, the series motor has the same problems of brush and commutator maintenance as found on d-c motors. Wound-rotor induction motors were also rejected because of the complication of slip rings, external resistances, and more complex wiring. A squirrel cage induction motor with high rotor resistance offers one solution to the requirements, but this construction reduces the motor torque and efficiency considerably as motor speed increases. That a high initial resistance is necessary can be seen from the equation for motor torque

$$T = K \phi I_r \cos \theta_r$$

where T equals torque, K is a constant and ϕ, I_r and Cos θ_r are the stator flux, the rotor current, and the rotor power factor respectively. In a squirrel cage induction motor, the max slip, i.e. the max ratio of the difference between synchronous speed and rotor speed to synchronous speed, occurs during starting. This slip causes an increase in the induced current frequency in the rotor windings, and therefore an increase in the reactance of the rotor, since reactance is proportional to frequency. Increased reactance, in turn, causes the rotor current to lag behind the voltage. Down to the point of max torque for any given design, current value has a great effect on torque than does the phase relationship; beyond that point, the phase relationship becomes more important, so that even with increased current, the torque becomes smaller. Actually, were it not for losses, the torque of an induction motor would be zero at zero speed, for the current would lag the voltage by 90 deg. and Cos θ would be zero.

By adding resistance to the rotor circuit, the current is brought closer into phase with the flux, and the torque reaches a max value. However, as rotor speed increases and slip decreases, the current and voltage come closer into phase, but the rotor current is decreased by the resistance in the circuit. It is obvious that the ideal solution to this dilemma is an infinitely variable resistance that would automatically decrease from a max at zero speed to a min at rated speed.

One way by which this has been accomplished is by the use of double squirrel cage rotor, which utilizes the so called "skin effect" of a-c current. Such a rotor has a double bar construction, two modifications of which are shown in Fig. 2. At high slip, the current flows in the top section of the double bar because of the high reactance of the long rectangular coil. The resistance of this smaller conductor is three to four times that of the conventional rotor bar, and the $I^2 R$ loss is proportionately higher. As the motor speed increases, the slip decreases, and the reactance of the rectangular bar becomes less (due to lower induced frequencies), the current is distributed over the entire cross sectional area, and the $I^2 R$ losses approach d-c values. While the additional resistance in the circuit gives max torque at starting, it also decreases the rotor speed about 20 percent below synchronous speed at full load. In addition, while such motors usually are cheaper than motors with multiple stator windings they are more costly than standard squirrel cage motors. This double bar construction is used extensively in small motors.

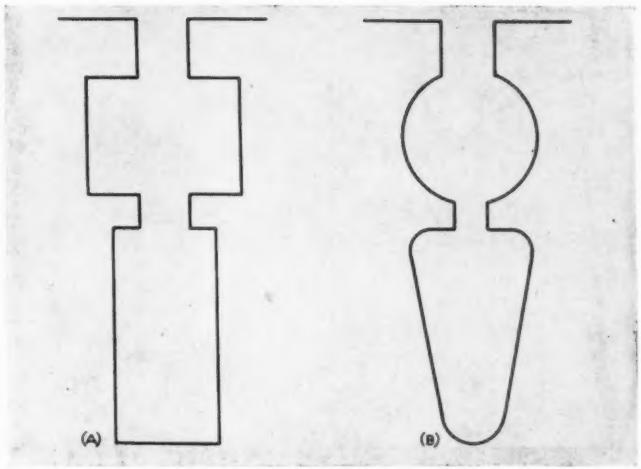


Fig 2—Two types of double-bar construction often used in the rotors of squirrel cage induction motors to obtain increased resistance in the rotor circuit.

Another method of changing resistance involves centrifugal mechanical devices. However, such devices are usually complex and may present a maintenance problem in service, particularly on equipment subjected to such rough usage as earth moving machinery.

The resistance element finally developed employs an entirely new concept. It is a stainless steel stamping made of 18-8 material that also doubles as the motor cooling fan. The

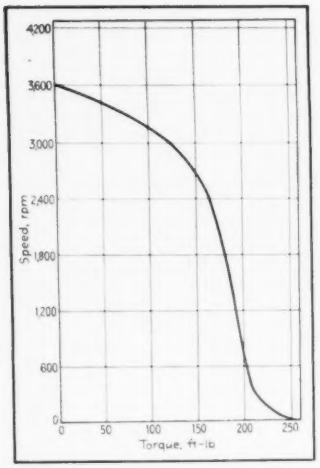


Fig. 3—Torque-speed curve for an 80 hp motor having a fan in the rotor circuit

Fig. 4—Motor and brake assembly for one of the new 120 cycle, a-c motors. When the magnets are deenergized, spring pressure applies the brakes, which hold the load.

rotor bars are welded to this stamping, so that the sections between bars act as resistances in the rotor circuit. When the motor is connected to a high torque load, induced currents heat the stamping. Since the resistances of the material at 1100 F is 44 microhms per cubic in. as compared with 28 microhms per cubic in. at 68 F (20 C), the increase in resistance is high enough to cause high starting torque in the motor. As the speed increases, cooling air flows over the stamping reducing its temperature and resistance. This reduction causes a higher full-load speed and better efficiency than would be obtained from a fixed resistance. High heat dissipation is possible because heat generation is localized in the air-cooled, fan stamping. Little heat is liberated in core slots because of large, low-resistance bars. Eddy current heating in laminations is reduced by drawing cooling air through axial holes in the core. An operating curve for a motor of this type having a hp rating of 80, is shown in Fig. 3.

Thus is the requirement of a high starting torque met. Such motors are now being used as auxiliary drives for aprons, tailgates, steering controls, winches, and other components of earth moving equipment. In addition, industrial applications for these motors can be found in many fields. The load curves of electric hoists are almost exactly the same as the equipment for which these motors were designed. Reversing drives on heavy equipment also represent possible applications. Flywheel-equipped machines require a high-slip motor so that the working stroke and subsequent motor slow down does not cause damaging overloads; in these cases, the high starting torque of the motor would also be useful in overcoming flywheel inertia during machine acceleration. For industrial applications, the motor design can be modified to permit operation on standard 60 cycle—120, 220, or 440 volt current.

There are a number of other modifications that can be made in the motor design should better full-speed operating efficiency and lower starting torque ratings be desired. For example, part of the fan resistance can be shunted out of the rotor circuit. A family of torque curves, can be obtained by such methods. As more rotor resistance is shunted out, the lower becomes the starting torque and slippage, and the higher becomes the full-speed operating torque of the motor.

Another obvious modification is the use of multiple stator windings. With the four pole motor and a single stator winding—standard on the new motors just described—the stator connections can be regrouped through suitable controls to form a two-pole motor, in which case the speed is doubled but the horsepower rating remains the same (the torque is halved). With a double stator winding, four-speed control can be provided. Steering motors for some construction equipment are built with two such windings; at the lower speeds the high torque ratings provide quick operation and therefore greater maneuverability; at the higher speeds, when the vehicle is operating as a faster rate, more sensitive control is obtained.

Other System Components

With the motor designed and the characteristics of the electrical system decided upon, two basic components remained to be developed: A brake, which would stop the motor quickly and hold any loads suspended in mid-air; and a generator, which would supply the necessary power to all motors in the system.

Automatic, multiple-disc brakes, Fig. 4, were developed as a part of the motor end bells. These brakes are spring applied and released by a six-pole, three phase magnet that is energized when power is applied to the motor. With three-phase current, there is less fluctuation in holding force than with single phase power and consequently, shading coils are not required to hold the load through the zero point of the current cycle.

The construction of the brakes is as follows: Metal lined friction discs are internally splined to mate with a seat on the motor shaft. Mating friction plates are mounted on three studs that form the brake frame. When the magnet coils are de-energized, spring pressure forces the metal discs against the facing plates, and the discs, being geared to the motor, stop its rotation. When the coils are again energized, the discs are released from contact and the motor takes over the load. A sectional diagram showing a

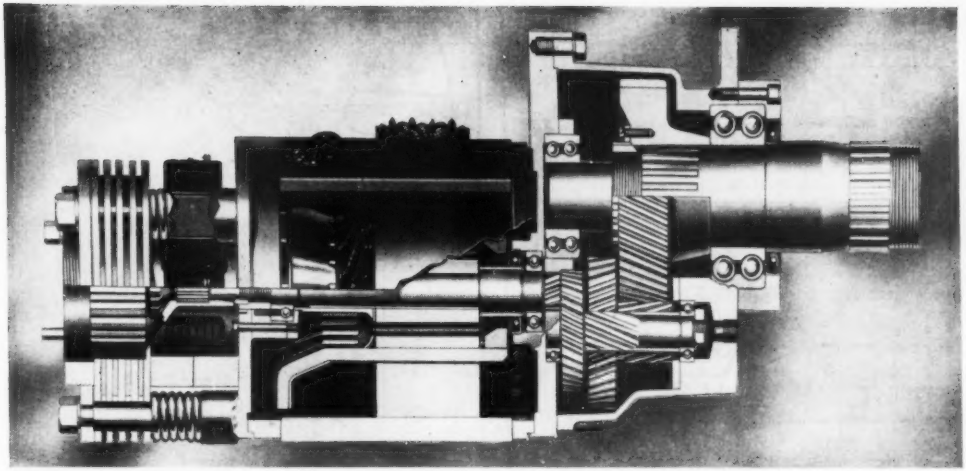


Fig. 5—Sectional diagram of the motor, brake and gear assembly for an auxiliary driving motor. Motors are made in different capacities to match the loads of the driven members. Some are also made with multiple stator windings for better speed control.

typical motor, brake, and gear assembly is shown in Fig. 5.

The alternating current generator for the system is connected directly to the vehicle engine, as shown in Fig. 6. The generator excitation circuit is designed to increase the output voltage as the load increases, thus increasing the output torque of the motors (as the square of the voltage). Two sources of field excitation accomplish this. A 24 volt vehicle storage battery provides the sole power source at no-load. To increase exciting voltage under load, the primary windings of a three-phase current transformer are connected in series with the generator output leads. The secondaries of this transformer are connected through a selenium rectifier to the generator field. As the load increases, the transformer secondary voltage increases and the resulting increased excitation raises the generator voltage. The rising voltage increases full-load motor speed and compensates for increased line losses.

The a-c generator is also used to charge the storage battery through another transformer and rectifier. This transformer is designed to provide stepless adjustment of charging rate without changing electrical connections. To accomplish this, the magnetic circuit between primary and secondary windings includes a movable "flux-bridge", which can be raised or lowered to change the reluctance of the magnetic circuit and consequently the transformer output.

Other components of the system are of conventional types. Overload protection is provided by thermostatic elements. The motors are energized through reversing contractors controlled by toggle switches.

As previously indicated, this electrical system has definite advantages over mechanical or pneumatic drives for the auxiliary mechanisms of earth-moving equipment when that equipment is large in capacity. It also is a convenient solution for the drives of other types of field equipment, such as hoists and derricks. And since the motors that were developed for this system have starting and operating characteristics not normally found in a-c units, they will undoubtedly find wide application in industry where the load characteristics of the equipment match with their torque curves. Especially should they prove adaptable to heavy machines that are equipped with flywheels, or that must reverse periodically in operation.

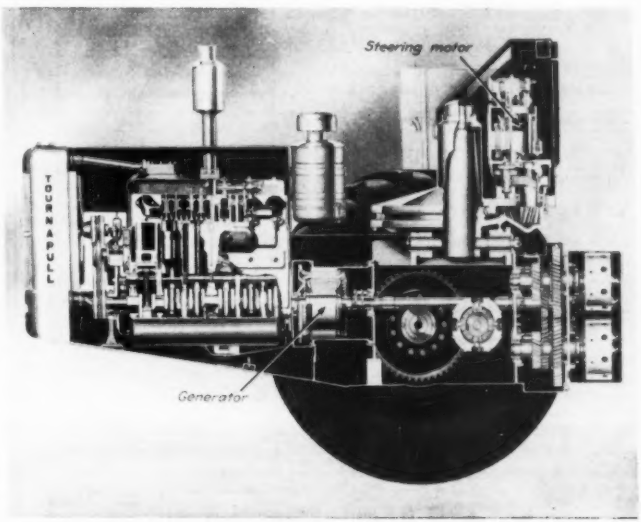


Fig. 6—The generator for the electrical system is mounted between the engine and transmission of a vehicle. The motor, upper right, is the steering control motor.

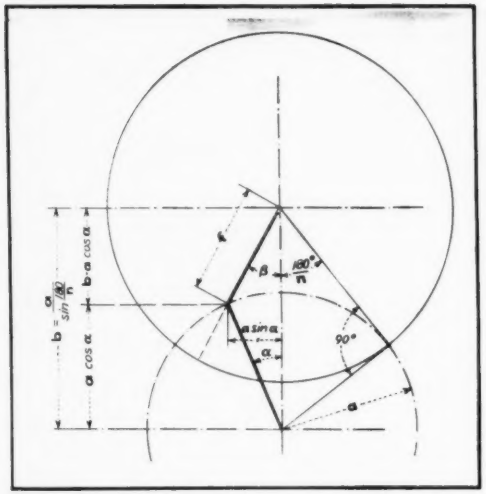


Fig. 1—Basic outline sketch for the external Geneva wheel. The symbols are identified for application in the basic equations.

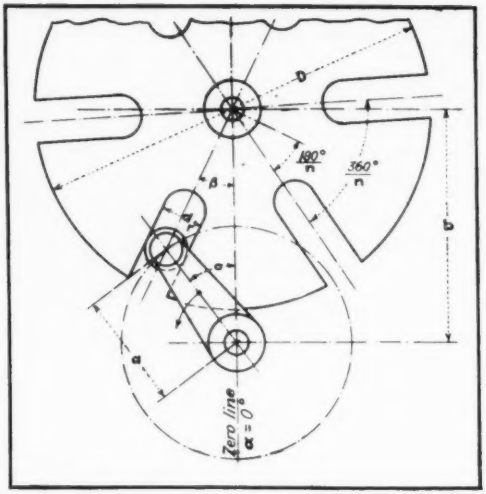


Fig. 2—Schematic sketch of a six slot Geneva wheel. Roller diameter, d_r, must be considered when determining D.

Kinematics of Intermittent Mechanisms I—The External Geneva Wheel

Table I—Notation and Formulas for the External Geneva Wheel

Assumed or given: a, n, d and p

a = crank radius of driving member

n = number of slots

d_r = roller diameter

p = constant velocity of driving crank in rpm

D = diameter of driven member $= 2\sqrt{\frac{d_r^2}{4} + a^2 \cot^2 \frac{180}{n}}$

$m = \frac{1}{\sin \frac{180}{n}}$

b = center distance $= am$

ω = constant angular velocity of driving crank $= \frac{p\pi}{30}$ radians per sec

α = angular position of driving crank at any time

β = angular displacement of driven member corresponding to crank angle α

$$\cos\beta = \frac{m - \cos\alpha}{\sqrt{1 + m^2 - 2m\cos\alpha}}$$

Angular Velocity of driven member $= \frac{d\beta}{dt} = \omega\left(\frac{m\cos\alpha - 1}{1 + m^2 - 2m\cos\alpha}\right)$

Angular Acceleration of driven member $= \frac{d^2\beta}{dt^2} = \omega^2\left(\frac{m\sin\alpha\,(1 - m^2)}{(1 + m^2 - 2m\cos\alpha)^2}\right)$

Maximum Angular Acceleration occurs when $\cos\alpha =$

$$\sqrt{\left(\frac{1 + m^2}{4\,m}\right)^2 + 2} - \left(\frac{1 + m^2}{4\,m}\right)$$

Maximum Angular Velocity occurs at $\alpha = 0$ deg, and equals

$$\frac{\omega}{m - 1} \text{ radians per sec}$$

ONE OF THE MOST commonly used mechanisms for producing intermittent rotary motion from a uniform input speed is the external Geneva wheel.

The driven member, or star wheel, contains a number of slots into which the roller of the driving crank fits. The number of slots determines the ratio between dwell and motion period of the driven shaft. Lowest possible number of slots is three, while the highest number is theoretically unlimited. In practice the 3 slot Geneva is seldom used because of the extremely high acceleration values encountered. Genevas with more than 18 slots also are infrequently used, since they necessitate wheels of comparatively large diameters.

In external Genevas of any number of slots, the dwell period always exceeds the motion period. The opposite is true of the internal Geneva, while for the spherical Geneva both dwell and motion periods are 180 degrees.

For proper operation of the external Geneva, the roller must enter the slot tangentially. In other words, the centerline of the slot and the line connecting roller center and crank rotation center must compose a right angle when the roller enters or leaves the slot.

Calculations that follow below are

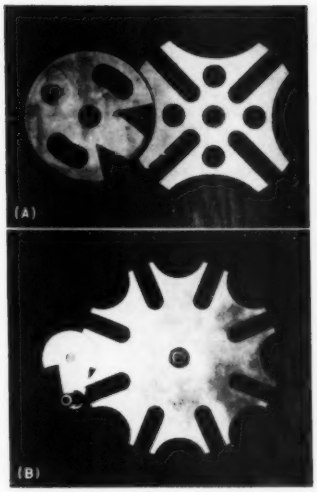


Fig. 3—Four slot Geneva (A) and eight slot (B). Both have locking devices.

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Consulting Engineer
Wright Machinery Company

based upon these conditions stated.

Consider an external Geneva wheel, shown in Fig. 1, in which

n = number of slots
a = crank radius

From Fig 1, b = center distance $= \dfrac{a}{\sin \dfrac{180}{n}}$

Let $\dfrac{1}{\sin \dfrac{180}{n}} = m$

then $b = a\,m$

It will simplify the development of the equations of motion to designate the connecting line of wheel and crank centers as the zero line. This is contrary to the practice of assigning the zero value of α, representing the angular position of the driving crank, to that position of the crank where the roller enters the slot.

Thus, from Fig. 1, the driven crank radius f at any angle is

$$f = \sqrt{(am - a\cos\alpha)^2 + a^2 \sin^2 \alpha} = a\sqrt{1 + m^2 - 2m\cos\alpha} \qquad (1)$$

and the angular displacement β can be found from

$$\cos\beta = \frac{m - \cos\alpha}{\sqrt{1 + m^2 - 2m\cos\alpha}} \qquad (2)$$

A six slot Geneva is shown schematically in Fig. 2. The outside diameter

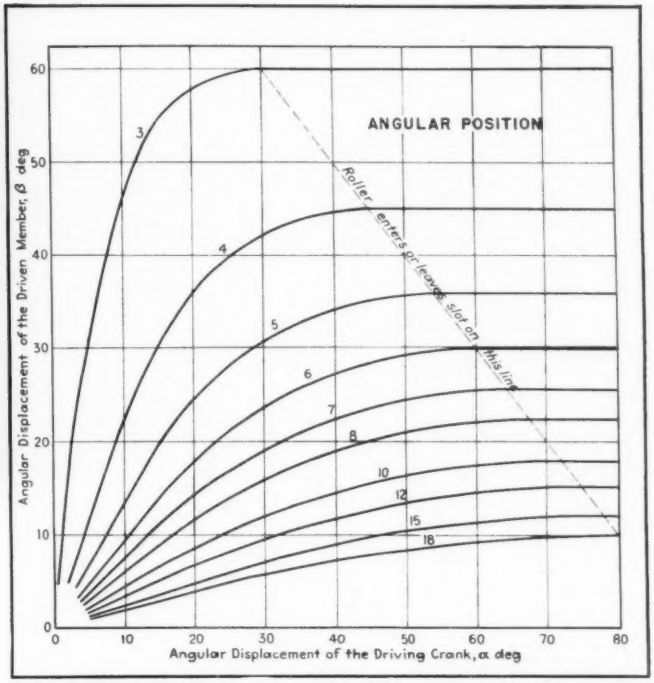


Fig. 4—Chart for determining the angular displacement of the driven member.

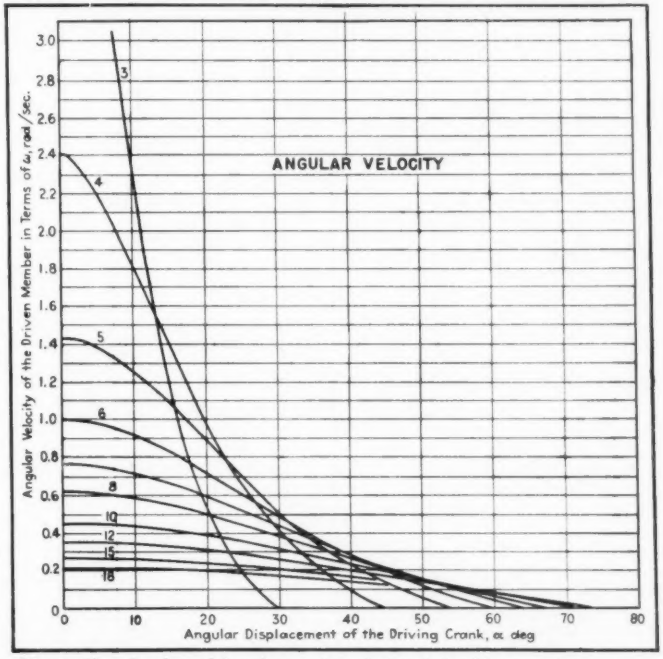


Fig. 5—Chart for determining the angular velocity of the driven member.

Table II—Principal Kinematic Data for External Geneva Wheel

No. of Slots	$\frac{360°}{n}$	Dwell period	Motion period	m and center-distance for $\alpha = 1$	Maximum angular velocity of driven member, radians per sec. equals ω multiplied by values tabulated. Crank at 0° position	Angular acceleration of driven member when roller enters slot, radians² per sec², equals ω^2 multiplied by values tabulated.			Maximum angular Acceleration of driven member, radians² per sec², equals ω^2 multiplied by values tabulated		
						α	β	Multiplier	α	β	Multiplier
3	120°	300°	60°	1.155	6.458	30°	60°	1.729	4°	27° 58′	29.10
4	90°	270°	90°	1.414	2.407	45°	45°	1.000	11° 28′	25° 11′	5.314
5	72°	252°	108°	1.701	1.425	54°	36°	0.727	17° 31′	21° 53′	2.310
6	60°	240°	120°	2.000	1.000	60°	30°	0.577	22° 55′	19° 51′	1.349
7	51° 25′ 43″	231° 30′	128° 30′	2.305	0.766	64° 17′ 8″	25° 42′ 52″	0.481	27° 41′	18° 11′	0.928
8	45°	225°	135°	2.613	0.620	67° 30′	22° 30′	0.414	31° 38′	16° 32′	0.700
9	40°	220°	140°	2.924	0.520	70°	20°	0.364	35° 16′	15° 15′	0.559
10	36°	216°	144°	3.236	0.447	72°	18°	0.325	38° 30′	14° 16′	0.465
11	32° 43′ 38″	212° 45′	147° 15′	3.549	0.392	73° 38′ 11″	16° 21′ 49″	0.294	41° 22′	13° 16′	0.398
12	30°	210°	150°	3.864	0.349	75°	15°	0.268	44°	12° 26′	0.348
13	27° 41′ 32″	207° 45′	152° 15′	4.179	0.315	76° 9′ 14″	13° 50′ 46″	0.246	46° 23′	11° 44′	0.309
14	25° 42′ 52″	205° 45′	154° 15′	4.494	0.286	77° 8′ 34″	21° 51′ 26″	0.228	48° 32′	11° 3′	0.278
15	24°	204°	156°	4.810	0.263	78°	12°	0.213	50° 30′	10° 27′	0.253
16	22° 30′	202° 30′	157° 30′	5.126	0.242	78° 45′	11° 15′	0.199	52° 24′	9° 57′	0.232
17	21° 10′ 35″	201°	159°	5.442	0.225	79° 24′ 43″	10° 35′ 17″	0.187	53° 58′	9° 26′	0.215
18	20°	200°	160°	5.759	0.210	80°	10°	0.176	55° 30′	8° 59′	0.200

D of the wheel (when taking the effect of the roller diameter d_r into account) is found to be

$$D = 2\sqrt{\frac{d_r^2}{4} + a^2 \cot^2 \frac{180}{n}} \qquad (3)$$

Differentiating Eq (2) and dividing by the differential of time, dt, the angular velocity of the driven member is

$$\frac{d\beta}{dt} = \omega \left(\frac{m \cos \alpha - 1}{1 + m^2 - 2\, m \cos \alpha} \right) \qquad (4)$$

where ω represents the constant angular velocity of the crank.

By differentiation of Eq (4) the acceleration of the driven member is found to be

$$\frac{d^2\beta}{dt^2} = \omega^2 \left(\frac{m \sin \alpha \,(1 - m^2)}{(1 + m^2 - 2\, m \cos \alpha)^2} \right) \qquad (5)$$

All notations and principal formulas are given in Table I for easy reference. Table II contains all the data of principal interest for external Geneva wheels having from 3 to 18 slots. All other data can be read from the charts: Fig. 4 for angular position, Fig. 5 for angular velocity, and Fig. 6 for angular acceleration.

Similar analyses of the internal Geneva wheel will be given next month, and for the spherical Geneva wheel will appear in a later number.

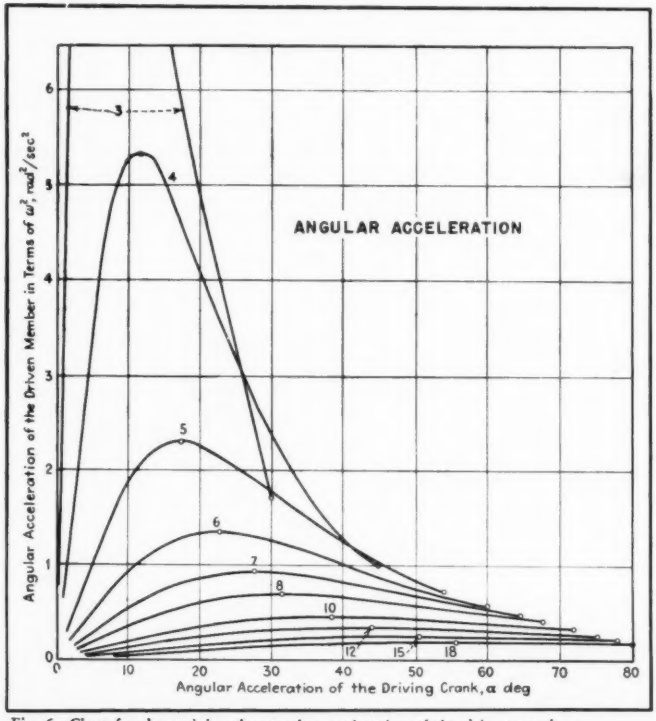


Fig. 6—Chart for determining the angular acceleration of the driven member.

"Give us the tools..."

YOUR ONLY CHANCE of Getting Ahead

Where is the "brave new world" so glowingly promised us by the politicians during and after the war? We were told then that postwar America would live 50% better than it had before. Why has that promise faded out? Why are men today discouraged and frustrated?

We have not yet made good 1944's promises because the *American worker turns out no more in an hour now than he did in 1941.* We are getting more total production in our country – but only because we have more people working. Not because each one of us is producing more. American industry's ability to turn out more and more goods – with less of each worker's time and effort – has been stymied for eight long years.

Progress has been blocked because in some cases workers have not been willing to work as hard as they did before the war. In other cases unions restrict the use of labor-saving machines and methods. In some places obsolete building codes and ordinances prevent advances. In still other cases progress has been blocked by collusive practices between unions and manufacturers or operators.

But the biggest block to progress is the fact that our industry in the United States has been unable to provide our workers with all the new tools and equipment that they need.

Increasing productivity – that is, each one of us turning out more in each hour of work – is the key to higher living standards. Productivity depends directly upon the kind of tools workers use. His tools, more than anything else, determine how much a worker can turn out; and what his paycheck will buy depends in large part on what he turns out – not on how long or how hard he works.

Look what happened in our country in the forty years from 1900 to 1940. Productivity of the United States *more than doubled.* It doubled because:

Business investment in capital equipment gave workers new tools – tools that had three and one-half times as much power –

So – Americans' living standard rose almost 50% while the average work week was dropping from 61 to 43 hours.

Industry did continue to raise its output per man hour, even in the depressed 1930's. But it did it because, with unemployment widespread, companies used only their most efficient equipment. *Actually the great depression saw industry fall far behind in the job of providing workers with new tools.*

Then came World War II. Few new tools for peacetime industry were produced. *As a result of depression and war, the U.S. fell behind in needed investment in new industrial facilities by more than $100 billion.*

Since the war business has spent almost $60 billion for new plants and equipment –

But the greater part of that money went to *expand* production to take care of the needs of our bigger population, and to *replace* plants and equipment that were worn out and ready to be junked at the end of the war.

continued on next page

Only a small fraction of the $60 billion went to *modernize equipment* – the equipment that increases efficiency and improves productivity of the individual worker.

Right now industry is desperately trying to do the job of increasing efficiency of machines so that each worker can turn out more.

McGraw-Hill's national survey of Business' Needs for New Plants and Equipment shows that manufacturers plan right now to spend in the 5 years ahead three-quarters of their capital funds to replace and modernize facilities. The biggest part of the more than $55 billion industry plans to spend on its plants and equipment will go directly to improve efficiency of the individual.

If industry can carry through its plans – and expand them as it would like to and as it must do – the U. S. can catch up on its depression-war-time lag in progress within a few short years.

If American industry is allowed to earn the money to buy the equipment, it can raise the American standard of living 50% in our generation – in the next 25 years. No other nation can promise its people that much – and deliver on the promise.

But the promise can only be fulfilled by American industry. Wherever you turn, industry has dramatic new ways of doing things. Using oxygen by the ton, steel makers are increasing production from blast furnaces by 20%. New high-speed machine tools are doing three times the work of 1940 tools. A new coal-mining machine will multiply a miner's daily output 10 times. Diesel locomotives do the work of three steam locomotives on many jobs.

New products – and larger production of standard products – are already making their impact on American life. Two million Americans will get new television sets this year. Automatic washing machines, electric dishwashers, and home freezers are easing the daily tasks of thousands of housewives. Millions of homes that did not have them before the war now have telephones, automatic heat and refrigerators. Frozen foods, nylon clothing – these and many other things coming along now – will shape the *real* new world for Americans.

But industry can provide them only if it can keep on investing at least $15 billion a year now – and more in future years – in new plants and equipment.

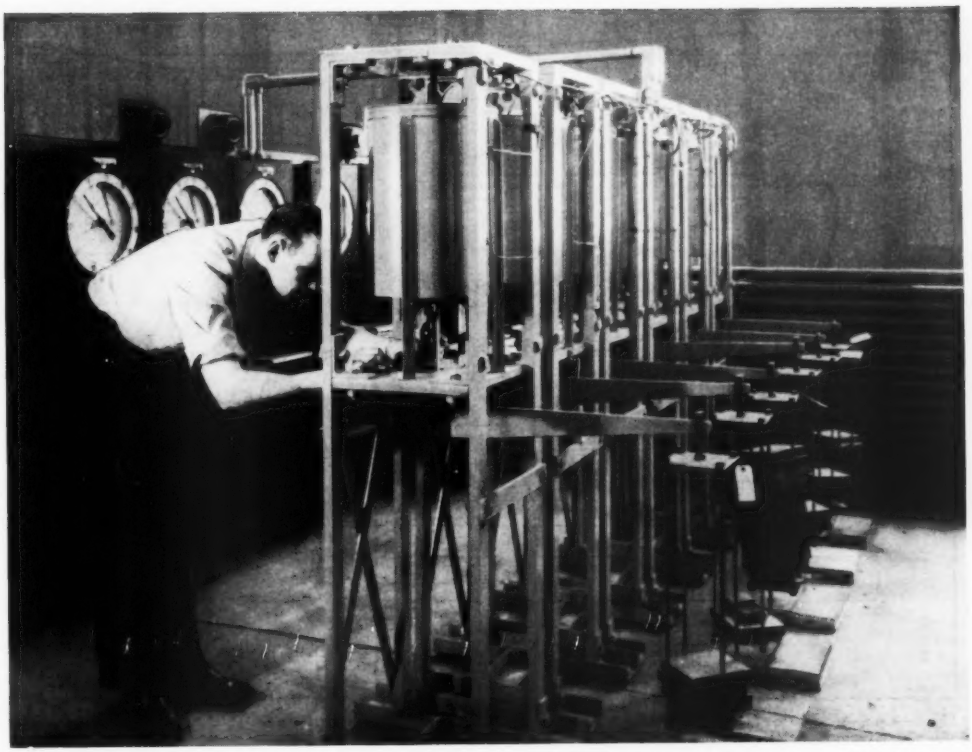
Today Washington is taking a course which, if pursued, will make that investment by industry impossible. Government spending now strains our resources to the limit, and more multi-billion dollar spending proposals are being piled on. *But government spending cannot improve American living standards.* It never has, and it never will. Increasing government spending *now* will only block progress, because the government proposes to pay for its plans by taxing away the profits industry is using, and must continue to use, to improve and expand its plants and equipment – our only hope for greater worker productivity and higher living standards.

Better living can only be paid for with more production. And we can only get more production by increasing productivity – by each one of us producing more for each hour of work.

The first thing is to get the production – in peace and in war – for better living – for security. Industry is planning to provide it – and is using $13 billion of its profits this year to improve and expand its facilities.

The only sensible, the only safe national policy is to make it possible for American industry to do its job – not to terrorize private industry with proposals of ruinous taxation and paralyzing controls and threats of nationalization. For American industry is not a thing apart from the American people any more than is government. American industry is the lifeblood of the American people and whatever makes industry do its work better contributes more to the common welfare than a bureaucratic government can ever hope to do.

President, McGraw-Hill Publishing Company, Inc.



TYPICAL STRESS-RUPTURE and creep-rupture testing equipment in Allegheny Ludlum high temperature alloy laboratory.

Selection of Heat Resistant Steels—I

Factors influencing the choice of a steel for high temperature service include strength, ductility and fatigue resistance at operating temperatures, as well as resistance to oxidation and corrosion caused by other media in contact with the metal. A wide variety of compositions are available for different conditions.

J. B. HENRY
Allegheny Ludlum Steel Corporation

SELECTION OF STEELS for service at elevated temperatures above 900 F, is a complex problem and usually results in a choice that is a compromise of a number of important fabrication and design factors:

1. Strength, ductility, and fatigue resistance at operating temperatures.
2. Resistance to oxidation or to the corrosive attack of other media in contact with the metal.
3. Retention of satisfactory mechanical and corrosion resistant properties after extended exposure to operating conditions.
4. Tendency to warp or to crack because of thermal stresses in applications involving intermittent heating and cooling.
5. Cost.

MECHANICAL PROPERTIES AT ELEVATED TEMPERATURES

When selecting alloys for strength in assemblies operating at temperatures under 900 F (approximately), design engineers rely on the short time tensile test, supplemented by fatigue and impact tests where fluctuating or shock stresses are involved. Over 900 F the yield point, as determined by the short time tensile test, is higher than the creep or stress-rupture strength; thus, in applications where stresses are applied over any appreciable time, creep or stress-rupture strength govern design. In structures operating above 900 F, time becomes a major factor in determining safe loading stresses, since the stress causing failure or maximum permissible elongation decreases directly as the time during which the stress is applied. Above 900 F, deformation under stress becomes plastic rather than elastic, since up to approximately 1200 F the flow is retarded somewhat by the accompanying work hardening.

The most useful test data for high temperature designs are derived from creep and stress-rupture tests (Fig. 1). These tests are similar in that a number of specimens are subjected to various

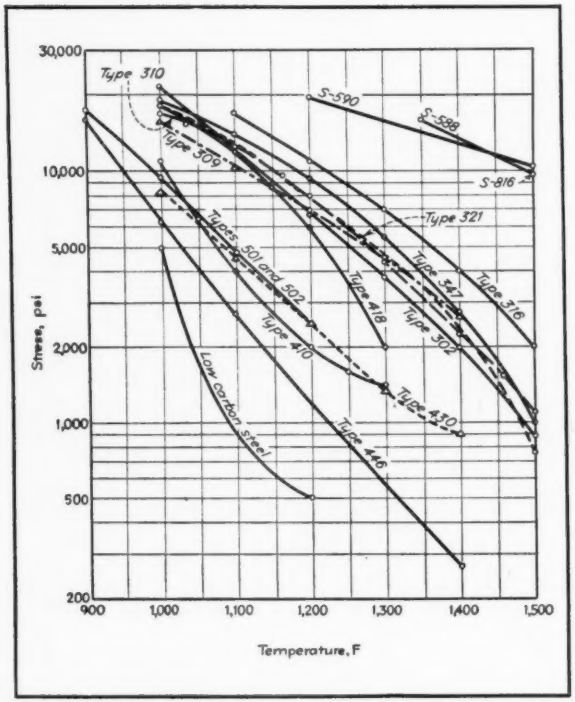


Fig. 1—Creep strength of the heat resistant alloys and three of the "super alloys" (constant rate of 1 percent creep in 10,000 hr at constant temperatures)

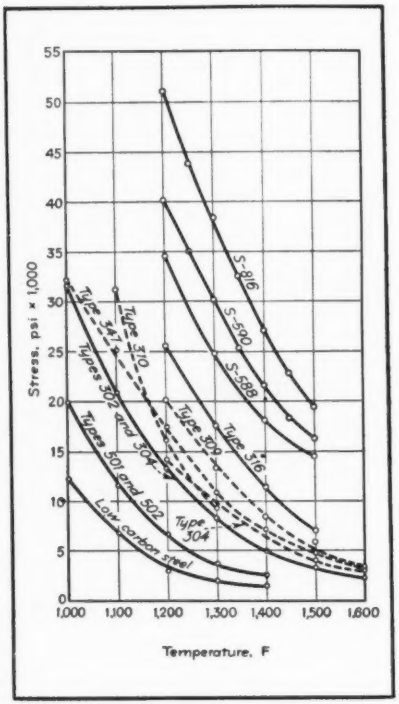


Fig. 2—Comparative stress of high temperature alloys necessary to cause rupture in 1,000 hr.

constant stresses at various constant temperatures. They differ in that applied stresses are much lower for creep rate determination, and elongation measurement must be more refined.

Creep tests are usually of 1000 hr minimum duration and results are plotted to show stresses that will produce a constant rate of elongation totaling 1 percent in 10,000 hr (0.1 percent in 1,000 hr) or 1 percent in 100,000 hr (0.01 percent in 1,000 hr) at various temperatures. The accuracy of extrapolation from 1,000 to 10,000 or 100,000 hr is questionable, although spot tests of duration up to 10,000 hr have verified the assumption that the creep rate remains constant at the rate determined from 1,000 hr tests. Fig. 2 gives a comparison of the creep strength among the alloys generally used for heat resistance; S-588, S-590, and S-816 are three of the so-called "super" alloys, whose chief application has been in highly stressed gas turbine components.

Fig. 3—Turbine nozzle (1st stage) of General Electric gas turbine for 4,800 hp locomotive drive.

Using Test Data

Stress rupture tests determine the length of time during which the specimen remains intact under constant loads at constant temperatures. Recently greater emphasis has been placed upon the deformation (percent elongation) caused by applied stresses over varying time periods. From these basic data are plotted curves showing stress causing rupture in 1,000, 10,000, or 100,000 hr (extrapolated) periods vs temperature, or curves showing stress causing rupture at the test temperatures vs time. The latter type of curve plotted on logarithmic scale is a straight line. As in creep data, the accuracy of extrapolation of curves to longer time periods is questionable, since the slope of stress vs time-to-rupture curve may increase, depending on internal stability of the alloy and the effect of surface oxidation. Additional tests up to 100,000 hr (over 10 years) are necessary to verify or correct the extrapolated values. For most applications, however, there is sufficient latitude, designers employing suitable safety factors such as 50 percent of the 1 percent creep stress in 10,000 hr. Comparative stress to cause rupture of high temperature alloys in 1,000 hr is shown in Fig. 3. Tests on S-816 in progress for over three years, and on S-588 and S-590 for over two years, show no change in the slope of the stress-rupture vs time curves; this indicates stability of structure.

Where close tolerances must be

maintained, designs are based on creep strength. For example, steam turbine parts are designed on the 1 percent in 100,000 hr creep strength. Where deformation under stress at test temperatures can be tolerated, safe working stresses are based on a percentage of the stress-rupture strength, for the anticipated service life.

Most highly stressed designs are based on both creep and stress rupture data. For example, creep strengths of alloys S-816, S-590, and S-588 at 1,500 F are all about 9,600 psi for 1 percent creep in 10,000 hr (approximately five times the value for AISI Type 316); yet, the stress-rupture strengths in 10,000 hr are nominally 14,500, 11,000 and 10,000-11,000 psi respectively, with 9, 11 and 7 percent elongations. Thus, while the deformation under stress of all three alloys would be constant under equal loading at a relatively low stress level, S-816, and to a lesser extent S-590, would give greater protection against failure caused by overload or stress concentration.

As the length of test time is increased, rupture fractures become characteristically intergranular and rupture occurs with successively lower ductility. This means that as stress is reduced, ductility prior to failure is likewise reduced. Retention of ductility is important, since it permits local elongation without failure during periods of overload, or permits relief of stress concentrations resulting from surface imperfections or transient thermal gradients. A minimum elongation of 5 percent in 2000 hr rupture tests is considered desirable.

High Temperature Fatigue Strength

Most high temperature applications do not subject the alloy to high frequency fluctuating stresses. Also, high temperature fatigue tests are difficult to conduct. Consequently, there is little data available on high temperature endurance limits, except for the "super alloys", which are used in rotors or rotor blades of gas turbines for their high fatigue strength. Unlike room temperature endurance limits, high temperature fatigue strengths cannot be considered the stress under which the material will withstand an indefinite number of stress cycles.

Creep and stress-rupture curves show that heat resistant alloys fall into four general groups in the order of increasing strength (see Table I for chemical compositions of the four groups):

I. The straight chromium steels of the 400 and 500 AISI series.

II. The chromium-nickel steels of the AISI 300 series, except Type 316.

III. AISI Type 316.

IV. The "super alloys", S-588, S-590, S-816, 19-9 DL, and similar alloys.

Of the Group I alloys, Type 418 ranks highest in elevated temperature strength, and at temperatures below 1,100 F is superior to Type 302. An interesting property of this alloy is its resistance to tempering. Fig. 4 shows the room temperature hardness of Type 418 and Type 410 (or 403) as heat treated to 300 BHN, after holding at 932 F. These data indicate the suitability of this grade from 700 to 1,100 F, where retention of heat treated strength and corrosion or scaling resistance is necessary.

Table II shows that hardened Type 418 tempered at 1,100 F for 992 hr retains a room temperature hardness of BHN 269, and indicates that this hardness would be maintained indefinitely. Table III shows the short time high temperature tensile test properties of this alloy at 932 and 1,100 F, with different heat treatments.

Grain Size

The effect of grain size on the strength and ductility of the high temperature alloys, particularly the austenitic grades of the AISI 300 se-

Table I—Composition of Heat Resistant Steels

High Temp. Strength Class	Type or Trade Designation	Allegany Ludlum Type	Principal Alloying Elements, Percent (Typical)								
			C	Cr	Ni	Co	Mo	W	Ti	Cb	Other
I	AISI 403	12-TB	0.12	12.3							
	AISI 405	12-NH	0.07	12.5							0.2 Al
	AISI 410	12	0.12	12.5							
	AISI 418	AM 12-W	0.12	13.0				3.0			
	AISI 430	17	0.10	17							
	AISI 446	28	0.12	25							0.25 (max) N_2
	AISI 501	46 M	0.15	5			0.5				
	AISI 502	46 SM	0.09	5			0.5				
II	AISI 302	AM 18-8	0.10	18	9						
	AISI 304	AM 18-8-S	0.06	19	9.5						
	AISI 309	AM 25-12	0.12	23	13.5						
	AISI 310	AM 25-20	0.12	25	20.5						
	AISI 314	AM 25-20-B	0.08	25	20.5						2.5 Si
	AISI 321	AM 18-8-T	0.06	18	9.5				0.40		
	AISI 347	AM 18-8-C	0.06	18	10.5					0.65	
III	AISI 316	AM 18-8-M	0.08	17	12		2.5				
IV "Super Alloys"	19-9 DL		0.32	19.5	9.5		1.25	1.35	0.35	0.40	
	S-816	S-816	0.38	20	20	42	4	4		4	
	S-588	S-588	0.42	20	20		4	4		4	
	S-590	S-590	0.42	20	20	20	4	4		4	
	N-155 (Low Carbon)		0.15	21.0	20.0	20.0	3.0	2.5		1.0	0.10 N_2

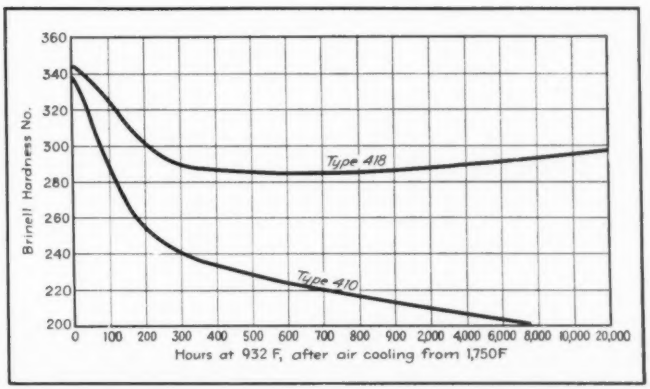


Fig. 4—Effect of tempering Types 418 and 410 (or 403) at 932 F, indicating suitability for service from 700 to 1,100 F, where retention of heat-treated strength is necessary.

Table II—Effect of Tempering Type 418 at 1,100 F on Hardness

Condition	Brinell Hardness No.
As Hardened: 1,800 F ½ hr, air cooled	415
As Hardened + 7 hr at 1,100 F	293
As Hardened + 26 hr at 1,100 F	277
As Hardened + 118 hr at 1,100 F	269
As Hardened + 214 hr at 1,100 F	277
As Hardened + 992 hr at 1,100 F	269

Table III—Tensile Properties of Type 418 at Elevated Temperatures

Condition	Brinell Hardness No. (70 F)	Testing Temp, F	Yield Strength, psi	Tensile Strength, psi	Percent Elongation, in 2 in.	Percent Area Reduction
1,800 F ½ hr, air cooled + 1,150 F 3 hr, air cooled	269	932	74,590	88,770	14.0	52.2
1,800 F ½ hr, air cooled + 1,350 F 4 hr, air cooled	217	932	56,460	78,000	15.0	46.2
1,800 F ½ hr, air cooled + 1,100 F 990 hr, air cooled	269	1,100	55,920	62,410	28.0	80.0

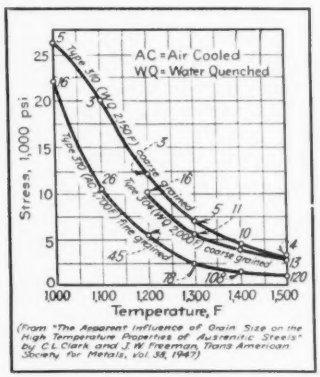
Table IV—Short Time Tensile Strength

(Sheet Specimens, Type 310, Test Temp. 1,400 F)

Carbon, percent	Grain Size	Tensile Strength, psi	Percent elong. 2 in.
0.071	Fine	31,270	36
0.073	Coarse	34,130	15
0.12	Fine	43,400	36
0.12	Coarse	30,300	9.5

ries, is marked. At all test temperatures in the range from 1,000 to 1,500 F fine grained austenitic alloys possess greater ductility than do coarse grained structures. With short testing times and at lower test temperatures, the finer grained structures possess higher strength, while with increasing test time and/or temperatures the coarser grained structures excel in rupture strength. Fig. 5 illustrates the effect of grain size on 10,000 hr stress rupture properties of Type 310, and for comparison also includes a curve for coarse grained Type 304. Table IV shows the effect of time of test—for shorter testing times the strength relationship between fine and coarse grained structures may be reversed, yet the ductility of fine grained material is superior regardless of test time.

Choice of fine grained or coarse grained structure depends on temperature and conditions of service. For example, substitution of fine grained Type 310 sheet for the usual medium to coarse grained material has greatly increased the service life of heat treating boxes or pans. Thermal stresses caused by rapid heating and cooling of containers made of the usual grain size sheets resulted in early failure by cracking. Substitution of fine grained sheet of higher ductility permitted relief of stresses by local elongation at points of stress concentration. When the quantity required permits special processing, alloys of optimum grain size for an application can be supplied.

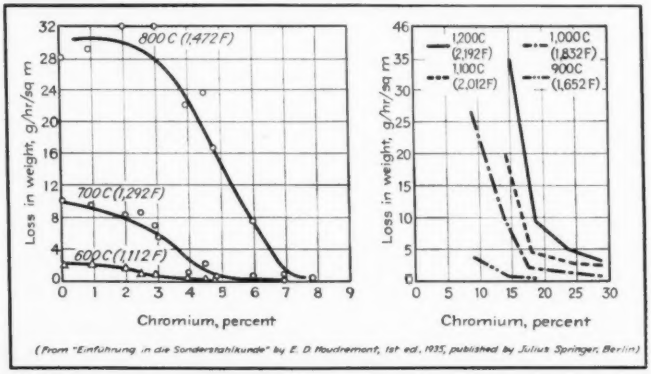


(From "The Apparent Influence of Grain Size on the High Temperature Properties of Austenitic Steels" by C.L. Clark and J.W. Freeman, Trans American Society for Metals, Vol. 38, 1947)

Fig. 5—Effect of grain size on high temperature strength and ductility; stress is that required to rupture in 10,000 hr. Numerals at plot points indicate average percent elongation at rupture for specimens of longest test.

Resistance to oxidation of the heat resistant alloys is directly proportional to their chromium content and to a much lesser extent, their nickel content. Chromium oxides in the scale form an adherent layer, resulting in a protective effect, illustrated in Fig. 6. Minor additions of aluminum and silicon have a similar effect, but with some undesirable characteristics. However, these curves cannot be applied quantitatively because of the inaccuracies inherent in measurement of reproducible values of weight loss (or weight gain) and the effect of minor changes in atmosphere. Fig. 7 presents the maximum advisable operating temperatures in still air.

Coefficient of expansion of the particular alloy influences resistance to destruction by oxidation. All of the chromium-nickel Type 300 series and, to a lesser degree, the "super alloys" have relatively high expansion rates; when temperature changes are drastic, failure through oxidation may be ac-



(From "Einführung in die Sonderstahlkunde" by E. D. Houdremont, 1st ed., 1935, published by Julius Springer, Berlin)

Fig. 6—Influence of chromium on the scaling of steel at: (left) 1,112-1,472 F in air; and (right) 900 C (1,652 F) to 1,200 C (2,192 F).

Chemical Resistance

celerated by spalling of the protective oxide layer. Fig. 8 gives a graphic comparison of the coefficients of expansion of the alloys. Of the 300 series, Type 310, because of its slightly lower expansion rate and possibly also because of higher nickel content in the protective scale, is satisfactory in many applications where spalling of protective scale renders other grades in the chromium-nickel group unsuitable.

Many parts, notably containers and fixtures for carburizing treatment, and equipment processing carbonaceous gases, are subjected to oxidation and carburization. When carbon diffuses into heat resistant steels their scaling and corrosion resistance is lowered. Carburization also causes embrittlement. Below 1,300 F the rate of diffusion of carbon into ferrous alloys is negligible. Over 1,300 F the straight chromium grades resist carburization up to the temperatures at which they begin transformation to austenite. Types 430 and 405 are resistant to about 1,700 F, higher than their maximum oxidation resistance and Type 446 is resistant at all temperatures of normal use.

For many applications, however, the use of a chromium-nickel grade is necessary because of strength requirements. In such applications, the addition of approximately 2 percent silicon to Type 310 reduces the carburization rate markedly. In the laboratory, test pieces were carburized 160 hr in solid carburizer at 1,800 F. In Type 310 of 0.07 percent C and 0.42 percent Si content, the carbon content increased to 0.28 percent at 0.010 in. depth and to 0.25 percent at 0.025 in. depth; with Type 310 of 0.042 percent initial carbon content and 2.15 percent Si, the carbon content at 0.010 in. depth increased only to 0.065 percent and at 0.025 in. depth to only 0.05 percent. This high silicon type, AISI 314, must be used with caution for reasons which will be outlined in a later section of this article.

Sulfur bearing gases at elevated temperatures have little corrosive effect on any of the straight chromium or chromium-nickel heat resistant grades, when the atmosphere is oxidizing and the sulfur exists primarily as sulfur dioxide. Laboratory tests ("High Temperature Corrosion of Stainless Steels", W. E. Fontaine, *Metal Progress*, September 1948) show negligible increase in scaling of Type 310 in an atmosphere containing 0.4 percent SO_2 (100 hr at 1,800 F exposure), compared with the effect of a sulfur free air atmosphere under otherwise identical test conditions. Table V shows comparative rates of attack in 100 percent

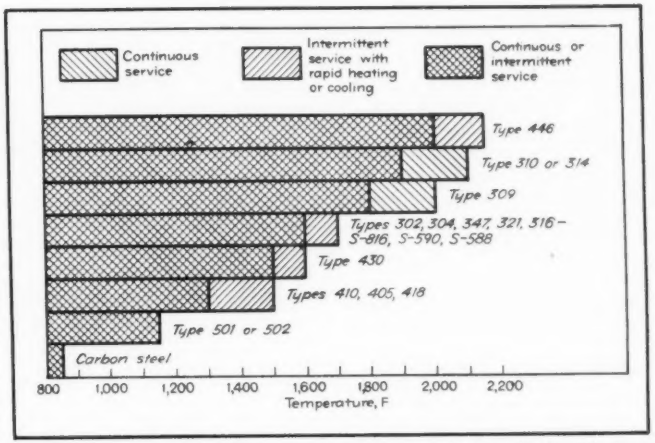


Fig. 7—Temperature limit of resistance to progressive scaling in still air. Maximum advisable operating temperatures in still air are determined by laboratory tests and field experience.

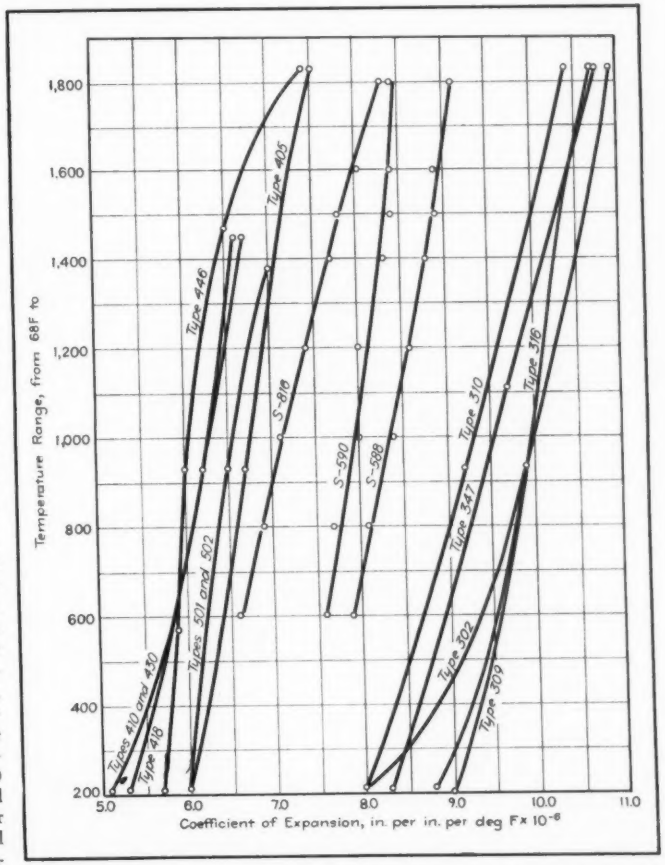


Fig. 8—Comparison of the coefficients of linear expansion of heat resistant steels.

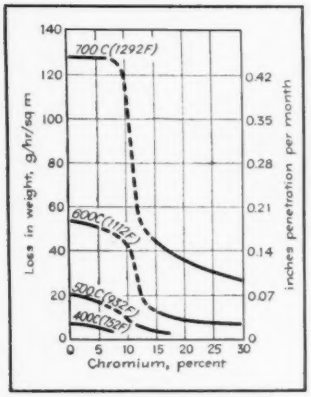


Fig. 9—Behavior of various chromium steels during hydrogen sulfide attack.

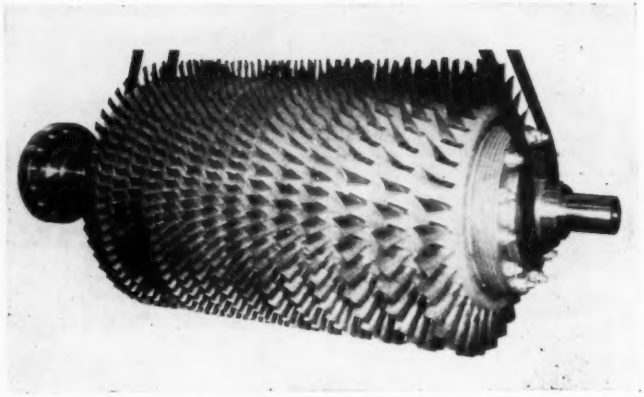


Fig. 10—Gas turbine power plant for General Electric 4800 hp locomotive drive. Shown here is compete assembly of compressor rotor, which is made of heat-resistant alloys.

SO_2 atmosphere on carbon steel and Type 347 steel.

In flue gas atmospheres containing sulfur dioxide, condensation of moisture can result in sulfurous and sulfuric acid solutions of concentration over 0.25 percent, which can cause pitting. In parts of such systems operating continuously below the dew-point of the atmosphere the use of Type 316 is advisable, because of its superior resistance to pitting in weak sulfuric acid solutions.

Table V—Comparative Rates of Attack by Sulfur Dioxide

Alloy Conditions	Rate of Attack Inches Penetration per Month
Common steel in pure SO_2 at 400 F	0 0003
Common steel in pure SO_2 at 1,200 F	0 070
Type 347 in pure SO_2 at 400 F	0 00009
Type 347 in pure SO_2 at 800 F	0 00055
Type 347 in pure SO_2 at 1,200 F	0 0025

Under reducing conditions, however, sulfur greatly accelerates attack on these alloys, particularly the nickel bearing types. Fig. 9 gives weight loss in a 100 percent hydrogen sulfide atmosphere, a much more severe condition than would be encountered in actual service. It illustrates the beneficial effect of increasing chromium content and the acceleration of attack with increasing temperature. Over 1,000 F, none of the chromium steels is sufficiently resistant to reducing gases containing an appreciable percentage of hydrogen sulfide. To determine the most suitable alloy for operation in sulfur bearing gases under reducing conditions, "pilot" tests are usually necessary. Basic data only can indicate the general type of alloy that might be sufficiently resistant.

Another source of accelerated attack on alloys at high temperatures is the action of particles of refractory or ash on the stable oxide scale. Such action varies with the composition of the particles and increases with the metal temperature. A contributory cause is the development of "hot spots", through the insulating effect of an adherent layer of oil ash or other solid materials which causes local temperatures to exceed the oxidation limit of the alloy. Type 446 is most resistant to the fluxing action of fly ash.

EDITOR'S NOTE: The second and concluding part of this article will be presented in the August issue.

Course on Computing Machines Sponsored by Government

A FORTY-EIGHT-LECTURE COURSE on the design of electronic digital computing machines is available to the American public from the Office of Technical Services.

Sponsored by the Army and Navy, the course was first given in 1946 by nineteen leaders in mathematics and electronics at the Moore School of the University of Pennsylvania, home of the ENIAC and EDVAC computers. The lectures have since been largely revised and collected for the use of researchers in this field.

Both practical and theoretical aspects of computing machines are discussed, and historical material is given tracing computing devices from the abacus to the mechanical, the electrical-relay and the electronic computer.

Limited supplies of the lecture series, in four volumes, can be purchased from the Moore School, University of Pennsylvania, Philadelphia 4, Pa., at $5 per volume. When this supply is exhausted photostatic copies can be secured from the Library of Congress, Photoduplication Service, Publication Board Project, Washington 25, D. C. at the following schedule of prices: PB 88012, $16; PB 88013, $18; PB 95645 and PB 95646, $20. Microfilm copies are also obtainable.

Also available from the Library of Congress is PB 96703 "Preliminary Discussion of the Logical Design of an Electronic Computing Instrument" prepared by the Institute for Advanced Study at Princeton, N. J. This 57 page report is available at $7.50 in photostat.

Library of Congress orders should be accompanied by check or money order payable to the Librarian of Congress in Washington.

Analyzing Equipment Operation by Photographic Measurement Techniques

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Ordnance Department, U. S. Army,
Aberdeen Proving Ground

PHOTOGRAPHIC MEASUREMENT is a method of analyzing the operation of a part, assembly, or mechanism from time-displacement data recorded on photographic film. It enables the designer to make a detailed study of the action of parts whose motion is either too complex or too rapid to be studied in any other way, and is especially advantageous when permanent records of the test results are required or when the operation of more than one part of an assembly must be studied.

A typical example of the type of information that can be obtained from a detailed photographic study is that resulting from an analysis of the ride characteristics of a vehicle prior to, during, and after negotiating a prepared obstacle, as illustrated in Fig. 1. This study revealed the extreme height and depth reached by the reference points, the speed of the vehicle, the time required to complete a cycle of oscillation, the time required for the oscillations to dampen out, and the rate of decelerations of the oscillations. Calculations then revealed the acceleration of the reference points at various stages of the action; the deceleration of the reference points due to impact; the stress placed on the part by impact with the ground (based on the weight of the descending part and the observed rate of deceleration); and the rate of increase and decrease of the stress.

Equipment Required

The photographic equipment, timing devices, and auxiliary apparatus that is required for an analysis depends on the type of information that it is necessary to obtain. The following equipment is usually sufficient for even the most complex analysis:

1. View or still type cameras, 4x5 to 8x10 in. in size.

2. Motion picture cameras, either 16 mm or 35 mm, ranging in operating

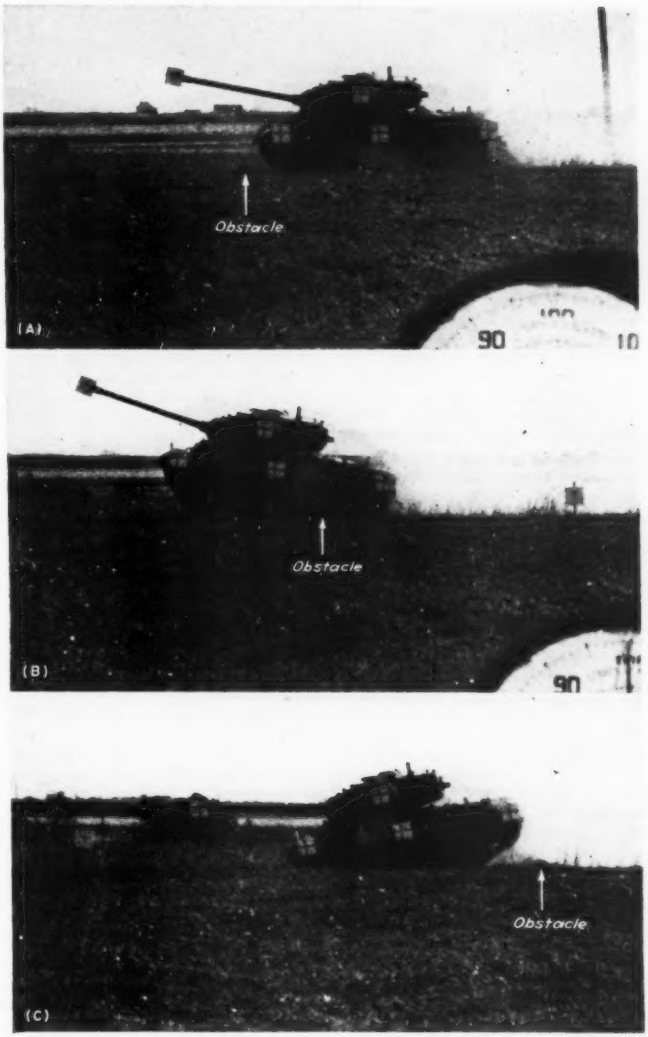


Fig 1.—Sequence photographs from a record film of a military vehicle negotiating an obstacle. View (A) shows the approach to the obstacle; view (B), the maximum "plus" displacement of the vehicle; and view (C) the maximum "minus" displacement.

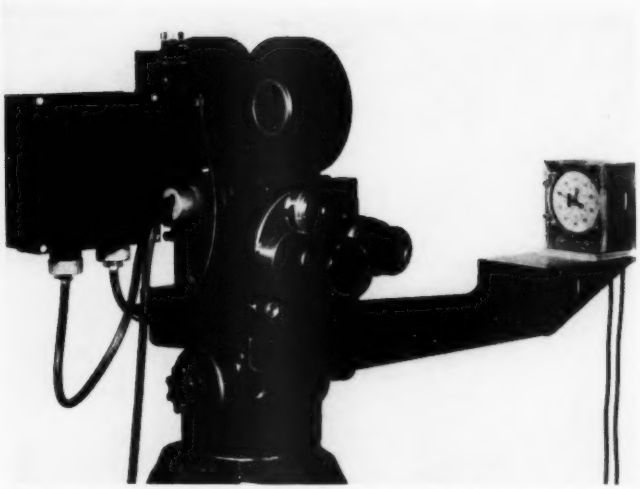


Fig 2—Chronograph type high-speed motion picture camera. The image of the clock is focused on the film by a special optical system, and the shutter that controls the exposure of the clock is synchronized with the main shutter.

speeds from 16 to 128 pictures per second.

3. Ultra-high speed motion picture cameras, 8, 16, or 35 mm, ranging in operating speeds from 200 to 8,000 pictures per second.

4. Micro-flash equipment and lamps for exposures on the order of 0.000001 or 0.000002 sec.

5. Miscellaneous photographic items, such as lenses, lights, timing units, electronic circuits, and light filters.

To time the action of the subject on the film, a synchronous motor-operated clock may be placed in the field of the camera. The standard clock has a one second sweep hand and is graduated in 0.01 sec. A 60 cycle frequency standard should be used to insure accuracy, and is essential when current is supplied from gasoline operated field generators.

If more convenient, the clock can be mounted on a bracket extending to the left of the camera, as shown in Fig. 2. A special optical system focuses the image of the clock on the film. The shutter that controls the exposure of the clock is synchronized with the main shutter.

For closer timing with cameras in which film motion is continuous (200 to 8000 pictures per second), electronic devices, utilizing neon or argon lamps, are used. The lamps are flashed by a condenser discharge circuit whose timing is controlled by an oscillating timing fork or quartz crystal. The lamp is installed in the camera as shown in Fig. 3 so that the image of the lamp is focused on the edge of the film independently of the camera shuttering. Successive time instants, at 0.001 sec intervals are recorded on the right hand edge of the film strip. A satisfactory lens for focusing the lamp on the film may be secured from a penlite flashlight.

Method of Procedure

In setting up a test, the specific area of the subject that is to be photographed must be determined. This might be a 3 by 3 in. area containing a mechanism that is a component part of a major mechanism; or it could be the entire area covered by a moving vehicle. The availability of space in which to locate the camera is also a vital factor. Consideration of these items will assist in deciding the optimum focal length camera lens to be used with a film of a given size. If the area to be photographed is large and the action of the parts within this area is slight, the subject may be photographed in sections, providing that sufficient camera overlap is allowed to assure that the action in one sectional view may be correlated to the action of the adjoining view.

The linear speeds of the points whose action is to be studied then must be estimated in order to determine the camera framing speed to be used. This distance in inches per sec divided by the number of frames per sec gives the amount of travel that will be recorded by the displacement indicated on two consecutive pictures. The desired magnitude of this distance will depend entirely on the character of the mechanism being studied. However, in order to get photographs showing sharp details, it may be desirable to use a higher framing speed to get a short exposure and thus sharp detail.

A high camera framing speed is necessary in determining the displacement limits of a fast moving reciprocating element. If the framing speed is too slow, the last increment of motion in reaching the extreme displacement might occur between frames. But, if the framing speed is sufficiently fast, it will be possible to establish the velocity curve and from that the accelerating curve, thereby making it possible to determine exactly the point of maximum displacement—this being where acceleration is zero. The size of the photographic image relative to the magnitude of the displacement must be sufficient to make it possible to measure the displacement correctly. In every instance it is the magnitude of the displacement as recorded on the film that determines the precision with which it can be measured.

If the subject has a repeating action, the frequency of the complete cycle must be considered. The time instant for the starting of the camera to record the required action must be determined. Plans for synchronization may also depend upon the amount of film which can be loaded into the camera for the operation, and upon the camera framing speed.

A micro-flash unit, and an ordinary view type camera, can be used to picture an action at maximum displacement or to picture the instant of contact of two objects, with no regard for the element of timing.

The most important step, of course, is to determine the type of information that is to be obtained from the test. For example, consider the case of a vehicle having a torque suspension system between the axle and body. The vehicle is to be dropped, free fall, from various heights to determine the amount of torque involved. The end product is to be time-displacement graphs, exhibiting the vertical motions taking place. Points on which measurements will be made are the hub of the wheel and a point on the body of the vehicle. These are the points whose positions will be plotted as a function of time. The position of these points may be measured relative to a fixed reference point such as a white line painted on the floor. From the time-vertical displacement charts can be determined such information as the instant of tire impact, the total compression of the tire, the height of rebound, and the cycling and dampening periods. The difference between

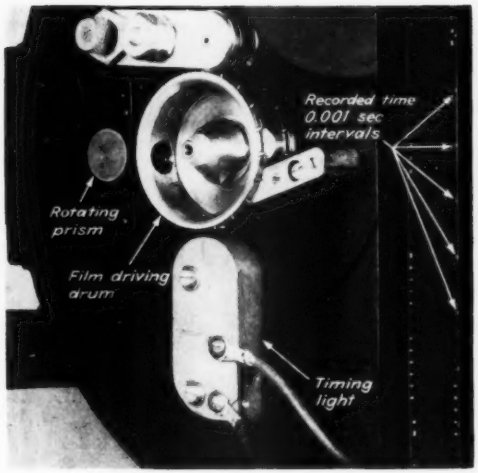


Fig. 3—Ultra-high-speed revolving prism type camera, with a timing lamp installed. Film strip shows positioning of the time marks on the edge of the film, 0.001 sec. interval apart.

Fig. 4—Synchronous motor-operated clock located in the field of view to obtain the time element. The reference points are for obtaining the conversion factor and vertical displacements.

the vertical position of the hub and body will provide data as to amount of torque. The graphs will reveal information as to "bottoming," i.e., how far the body descends before making contact with some part of the axle.

When it has been determined what information is to be obtained by measurement of the film images, the camera must be located at a distance from the subject that will give a suitable ratio of object to image (conversion factor), so that the actual movement of the recorded image can be determined from the film.

There are two common methods for obtaining conversion factors:

1. Conversion factor,

$$C = \frac{\text{distance from lens to subject}}{\text{distance from lens to film}},$$

the distances being taken from the nodes of admission and emission of the lens. Any linear distance measured on the film, when multiplied by the conversion factor, will yield the corresponding true distance in the subject plane. The drawback to this method is the difficulty of determining the exact distance from the lens to the films. A small error in this distance will affect the result much more than an error in measurement of the distance from the lens to the subject. Also, any appreciable movement of the subject either toward or away from the camera will result in inaccuracies.

2. After a camera set-up has been established and photographs secured, the conversion factor may be accurately determined by the ratio of the object size to the image size. In practice, two narrow lines, parallel with each other and separated by a considerable distance, or two small circles, similarily separated, are painted on the subject. The separation distances are measured and photographed. After the corresponding separation distance on the film is measured, the conversion factor is obtained by simple division.

In addition, it is sometimes desirable to compute the focal length, F, of the camera. This may be found by the formula

$$F = \frac{D}{C + 1}$$

where D is the distance from the object to the camera lens, and C is the conversion factor.

In the study of a moving subject, a white reference line is painted on the floor at approximately the same distance as the subject plane to serve as reference line for measuring vertical displacements. All displacement measurements taken from the film by means of a comparator will equal the actual displacement of the subject when multiplied by the conversion factor. Since all the points of interest will not lie in the same plane, it may be necessary to establish conversion factors for each plane considered. In the illustration of Fig. 4, two conversion factors were utilized, one from the rim to the hub, and another from two points above the wheel on the body.

To obtain displacements without the necessity of measuring the film, a grid, prepared by painting vertical and horizontal lines on a background of contrasting color, can be set up. The grid is placed a measured distance from the camera and parallel to the film plane. The intersection of a vertical and horizontal line is made to coincide with the optic axis of the camera lens, and the ends of these lines are marked. The subject is placed at a measured distance between the camera and grid. This grid method may be used when there is no motion of the subject toward or away from the camera, and when the motion of the subject is within the limited area defined by the grid.

If it is desired to obtain a single large photograph showing phenomena such as the relative positions of several points of interest during rapid motion, or the bending of members due to stress when at maximum displacement, the use of the micro-flash technique is recommended. In providing for the triggering of the unit, it is generally advisable to use a "make contact" circuit. Wires are placed on the subject and on some other member in such a manner that contact will be made at the position of interest, or at the point of maximum displacement. The position of the second wire will have to be determined by experiment. The points of interest should be painted a color that will contrast with the background, and a scale should be mounted in the field to provide means for obtaining the conversion factor. The subject may be photographed statically by initiating the flash unit by use of a wire across the triggering leads. The subject may then be photographed in motion. In micro-flash

photography the camera shutter may be opened before, and closed after, the flash of the lamp, since this operation is necessarily conducted in semi-darkness.

A thin coat of paint applied to the points of interest will facilitate the action photograph. Since white paint will produce irridation on the film until the camera has reached the framing speed for which the exposure has been calculated, a medium gray paint is recommended. When two objects are to be shown making contact with each other, both should be painted. This will assist in positive identification of the instant of contact when studying the processed film.

When the action to be photographed covers a large angular distance, telephoto lenses may be employed and the camera panoramed. However, since the linear distance from the camera to the subject will be varying, it becomes necessary to obtain conversion factors for each frame in which measurements of vertical displacements are to be obtained.

In tests where the desired displacements will occur in planes at an angle of ninety degrees to each other, two cameras are required, each with its own clock. The two time clocks are started simultaneously by means of a single starting switch. It is not necessary that the framing action of the two cameras be synchronized, but since the clocks are started simultaneously, displacements in one plane may be correlated with displacements in the second plane through interpolation based on the clock readings.

Measurement of Data

The extensive work of planning, and the preparations that have been entailed in conducting the test, can be nullified if a poor or inadequate measuring instrument is utilized in the study of the processed film. A precision instrument, having scales calibrated in 0.0001 in., 0.01 mm or 0.001 mm is desirable.

Projectors or comparators that employ transmitted light, that have provision for measurements in two coordinate axes, and that incorporate an angle measuring device are well suited for many types of film measurements. An eyepiece magnification of from 3X to 5X is usually found to be adequate.

The measurements that first should be obtained in several frames are the distance between centers of the lines or circles on the subject while the subject is static for determination of the conversion factor; and the distance between the stationary reference line and each reference point involved in the action of the subject. A study of these will reveal the magnitude of the possible error incurred in measuring. As an example, the following repeated measurements of the distance between two image points were obtained: 0.0230, 0.0227, 0.0228, 0.0230, 0.0226, and 0.0228 in. The average of these is 0.0228 in. and the extreme deviation is ± 0.0002 inch. The corresponding deviation in the subject plane is the product of the extreme deviation from the average and the conversion factor. Any change in scale of the film due to the chemical processing and drying procedure does not affect the possible error since the measurements and the conversion factor pertain to the processed film.

Measurements relative to the stationary reference line, or other reference points to each reference point involved in the action of the subject are useful both for determining the possible error and for establishment of "zero" distances. The average of the measurements of each distance concerned becomes the "zero" distance to which all subsequent action displacements are referred. Since the subject is at rest when the "zero" measurements are recorded photographically, any deviation from the measured "zero" provides the desired information regarding action displacements.

With the conversion factor, possible error, and "zero" distances established, the distance from the stationary reference point or line to each subject reference point on the subject in motion then is measured. It may not be necessary to make measurements on every frame to obtain the desired information. The frequency of the measurements will depend upon the speed of the subject action, the increment of time used as a base, or on some preselected time interval. Measurements are made of each distance, covering the entire action of the subject. Sufficient frames should be measured to insure that no further action of the subject is to be expected.

Upon completion of all the measurements, the difference between the "zero" distance and the reference points is in each case obtained. The differences multiplied by the conversion factor indicate the motion or displacement of the reference point from the static position.

Data Obtained from Grid Background

When the grid-background method of recording displacements is employed, a comparator is not required. A projector, having a magnification of 10X or greater is used to project the images on a screen. A frame showing the subject in static position is projected on the screen. The location of the points of interest, relative to the nearest horizontal and vertical grid lines, is recorded as the number of the grid line above or below, right or left, from the grid line intersecting the optic axis of the lens. This procedure is continued through several frames to determine possible camera motion due to vibration.

The apparent position of the points of interest relative to the grid lines then is recorded for successive frames until all action of the subject has ceased. Before discontinuing the measurements, it should be definitely verified that no further motion of the subject will take place.

When all the reading measurements have been made, the process of converting these values to ascertain the actual movement of the subject is begun.

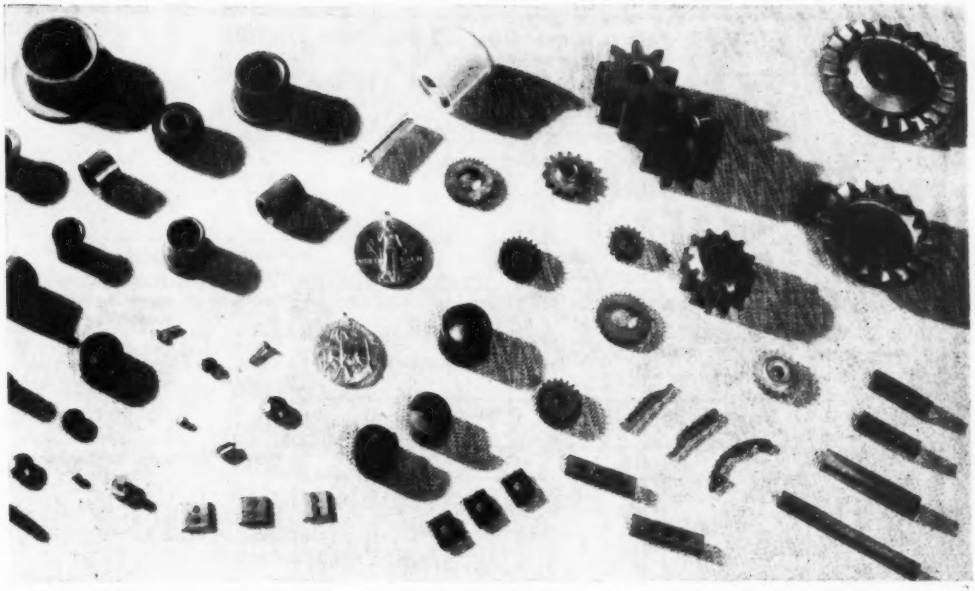
The following distances are known: the grid distance from the optic axis to the extreme line intercepted by the subject, the distance from the camera lens to the grid, and the distance from the camera lens to the vertical plane containing the subject point of interest. The desired information may be derived by use of the following formula,

$$\text{Subject position} = \frac{GG}{CG} \times CS,$$

where GG is the vertical distance on the grid from the grid line on the optic axis to the farthest line intercepted by the subject; CG is the horizontal distance from the camera lens to the grid line on the optic axis; and CS is the horizontal distance from the camera lens to the vertical plane in which the reference point is located.

The information desired is the displacement of the subject from its static position (zero position). The displacement is the difference, up or down, right or left, between the static position of the subject and its displaced position. Do not let the sign of the values cause confusion. For example, if the reading on the subject, static position, is -6, and in motion -4, then the displacement is $+2$. On the other hand, if the subject, static position, reads -6, and in motion -8, then the displacement is -2. When it is required to make a study of the displacement of several reference points relative to each other, the first step is to determine the motion of these points relative to the stationary reference point or line. From this data the relative motion of the points may be computed.

The methods for securing engineering data by the techniques discussed in this article do not, of course, begin to exhaust the possibilities.



COMPLEX SHAPES are especially adaptable to the powder metallurgy process because subsequent operations are unnecessary.

Scope and Limitations Of the Powder Metallurgy Process

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TO OBTAIN the best product at the lowest unit cost, it is necessary for the designer to recognize the limitations as well as the advantages of the process by which the part is to be produced. Especially is this true of the powder metallurgy process, because of the many variables that may effect part strength and performance.

Powder metal parts are practical when the quantities that are to be made are 25,000 or more, although in some instances lots of less than 25,000 are practical. The types of parts that can be adapted for this production process can be broken down into four categories: Mechanical, electrical, structural, and special.

Mechanical parts, such as cams, gears, plain sleeve bearings, and self-aligning bearings, are well adapted to the process primarily because complex shapes can be formed that would be difficult or impossible to machine or forge. Part density can be controlled within a range of about 5 to 6.7 grams per c.c. for ferrous parts, and over a much greater range in non-ferrous parts, so that weight is lower than a comparable part made of solid metal. Also, the part can be impregnated with oil, graphite, or other lubricants to cut down friction between mating members.

Electrical parts made of bronze (90 Cu-10 Sn), and copper silver (98 Cu-2 Ag) and pure copper have good electrical properties and in many cases are considerably cheaper than forged or stamped members. A part pressed of pure copper powder has an electrical conductivity up to 85 per cent of the conductivity of commercially annealed sheet. It usually has better anti-weld properties. Abrasive materials such as talc or alundum powder can be added to make contact points and magnetic parts for d-c applications. In a-c applications, high eddy current losses limit the use of core parts. Some work has been done on the use of powder metal parts as commutator bars and segments. Indications are that some advantages can be obtained by use of the process.

Structural parts, such as spacers, blocks, brackets, and housings have the same advantages and applications as mechanical parts. Special parts, including filters, catalysts, ornaments and medallions, are pressed of powder either because their micro-porosity makes them adaptable to the filtering of gases or fluids, or because the transfer of fine detail from punch to part is better than by coining processes.

Most parts are made from alloy steel, iron, copper, bronze, brass or nickel-silver powder. A number of typical powders are listed in Table I together with the properties of a test specimen made from them. The physical properties given in this table are average values. The strength of any sintered part depends on the density

Table I—Physical Characteristics of Powder Metal Test Bars

Metal	Percent Porosity	Tensile Strength, psi	Compression Yield, psi	Modulus of Rupture, psi	Elongation, percent	Density grams/cc	Remarks
Bronze Cu 90 Sn 10	27	11,000	8,500	15,300			Used for bearings. Good anti-galling and corrosion resistance.
	18	17,000	15,400	35,000			
Bronze Cu 90 Sn 10	28	12,000	9,200	15,800			Same as above, but has more ductility.
	18	20,000	16,500	37,000			
Iron (no carbon)	30	13,000	21,500	26,000			Used as a substitute for bronze in low cost applications.
	30	24,500	38,000	51,000			
Iron (2 percent carbon)	25	40,000	50,000	59,000			For bearings supporting low speed shafts. Can be machined.
Iron (with some copper)	18	30,000		55,000			Used for fine tooth gears, lightly loaded, such as clock and timing gears. Easily machined.
	20	45,000		73,000			Used for gears requiring greater wear resistance and load carrying capacity.
	6	75,000		142,000			Used for highly loaded gears.
Brass Composition Cu Zn P							
70 30 —		36,000			14	7.92	Brush holders.
70 30 0.3		36,000			48	7.92	Ornamental pieces.
85 15 —		37,000			15	8.24	
90 10 —		32,000			14	8.36	
90 10 0.5		32,000			34	7.99	

of the sintered piece, the kind of powder used, and the sintering time and temperature.

The chief determinant of part properties, exclusive of the material used, is the molding pressure. At pressures over 100,000 psi, the density of powder metal specimens approaches that for metals in wrought form. Consequently, dies and punches are heavily loaded and must be designed to withstand high loads without deforming or breaking. This requirement is reflected in the design procedure applied to parts made in these dies.

The flow characteristics of metal powders also has an important bearing on design. For the most part, metal powders flow very little when compressed. They will not flow around sharp corners to fill out horizontal projections. Movements in the direction of pressing comes about only through compression. Even then if the die space is long and narrow in the direction of pressing, powders cannot be expected to compress uniformly. Side wall friction may be large enough to use up a large percentage of the available punch load, leaving little for compressing the powder near the bottom of the die cavity in single moving punch set-ups, or in the middle of long parts when compacting takes place from both ends of the die.

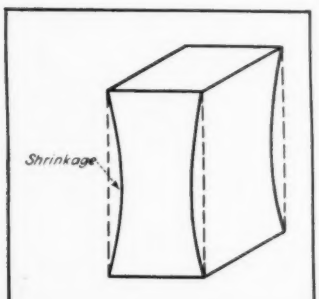

Fig. 1—Large parts have a greater tendency to shrink or distort when sintered.

As a result long narrow parts usually vary in density depending on the location of the cross-section checked. Large counterbores also can cause powder pile-up and large variation in density. Open shell parts may warp during sintering and parts with large variation in thickness may develop high internal stresses resulting in non-uniform shrinkage during sintering.

Design Limitations

Although it is difficult to formulate a series of design rules that take into account all these variables and list the exceptions that can be made, the following limitations can be used as general guides when designing a part:

SIZE OF PARTS. Because variations in the uniformity of mold fill, powder composition, and grain size have a more serious effect on large parts than on small, most mechanical and structural pieces produced by the powder metallurgy process do not measure more than three inches in width and two inches in length. Large parts usually are less dense than small members with the result that control of shrinkage and distortion during the sintering operation is intensified, as illustrated in Fig. 1.

There are, of course, exceptions: Some low density bearings and filters have been made in sizes up to 22 in. diameter. At the other extreme parts as small as $\frac{1}{32}$ in. are practical.

SHAPE OF PARTS. The ideal part resembles a section of extruded bar or tube stock having either a regular or irregular cross section. Sharp variation in thickness in the piece in the direction of pressing must be avoided. Irregular parts should be designed so that only one end—preferably the bottom—is complicated by holes, counterbores, projections, or slots. These points are illustrated in Fig. 2. Actually any shape that can be hobbed into the tool can be pressed of powder. Spherical shapes are not too practical to press unless provided with a land and flat, as shown in Fig. 3, to prevent contact of the upper and lower punch.

PART PROPORTIONS. The following recommended maximum relationships

of length to width insure fewer rejections and lower part cost when parts are molded in the standard way (vertical to the punch action).

Diameter	Max. Length
⅛ in.	½ in.
¼ in	¾ in.
½ in	1.0 in
¾ in	1½ in.
1.0 in.	2.0 in.

If the part is so shaped that it can be pressed horizontally, the above relationships do not hold.

TOLERANCES. Variations in the final dimensions of a powder metal part are the result of die tolerances, die deflection and shrink or swell during sintering. In low density parts, dimensional variations are likely to be greater than for high density parts. But by allowing for shrink or growth when the die and punch are made, these effects can be offset to some extent. The more symmetrical the part, the better tolerance that can be obtained. On simple round shapes, the following tolerances are commercially practical:

Diameter	Tolerance
½ in.	±0.0005 in.
¾ in.	±0.0008 in.
1.0 in.	±0.001 in.

The proportions are quite similar in larger sizes. The minimum tolerance in the direction of pressing varies from 1 to 3 times that of the diameter, depending on the material being pressed and the proportions of the part.

Closer tolerances than these are possible if the part can be coined or sized, but these are supplementary operations that add to part cost. If price is of no importance, a tolerance of ± 0.0001 in. can be obtained by coining.

WALL THICKNESS. It is difficult to get uniform die fill in narrow, deep parts. Hence the minimum wall thickness varies with depth. Unless requirements are fixed, parts should have a wall thickness greater than 0.045 in. Thickness for design are

Wall thickness	Depth of part
0.032 in.	0.25 in.
0.045 in.	0.50 in.
0.050 in.	0.75 in.
0.062 in.	1.00 in.

DRAFT. Little if any draft is required on straight symmetrical parts. On parts having flanges or overhanging projections, such as shown in Fig. 4, draft is added to the projection to facilitate ejection from the mold without breaking the part. Grooves or indentations formed by the upper punch must have a small draft; 0.001 in. is ample in most cases.

CHAMFERS. No chamfer should be provided on the outside edges of a part unless absolutely necessary because feathered edges on a punch have a tendency to chip. Round punches can be redressed, but other shapes are difficult to grind; on irregular shaped pressings, chamfers are impractical. Rounded corners are even more difficult to obtain. If chamfers are necessary for the proper functioning of the part, a small flat should be provided, as indicated in Fig. 5.

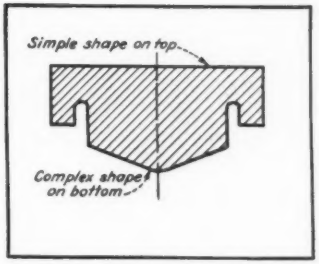

Fig. 2—Complex shapes should be specified only on one end of the part.

On the other hand, chamfers on the edges of a cored hole or at the end of blind holes are desirable. A 45 deg. chamfer is the most satisfactory.

RELIEF. Sharp corners on the underside of flanges or in cored holes should be avoided. For parts that are to be sized, 0.005 in. to 0.001 in. relief should be provided; it allows the sizing tool to "bottom" and form a sharp corner. For unsized parts, a radius of 0.010 in. can be specified. These principles are illustrated in Fig. 6.

RIBS. Unlike die cast parts, pressed metal parts should be designed without ribs if possible. Ribs do not aid the powder flow, require more material, and often result in non-uniform densi-

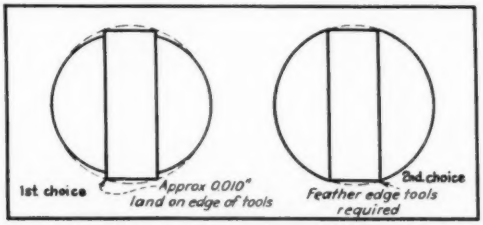

Fig. 3—Two methods of designing a spherical part. With the design at the left, grinding of the punch is simplified.

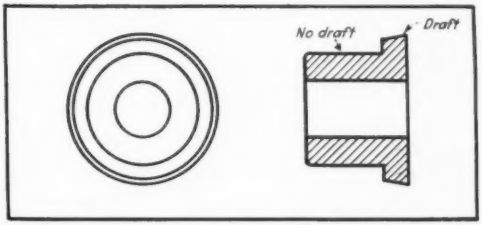

Fig. 4—Draft is necessary on overhanging projections or on indentations so that the part is not broken when ejected.

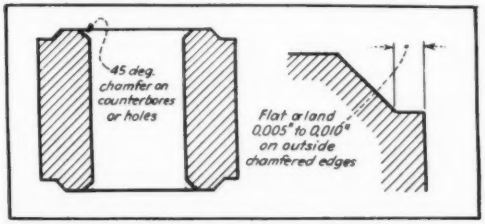

Fig. 5—Outside edges should be landed if chamfered so that there is no necessity for feather edges on the punch.

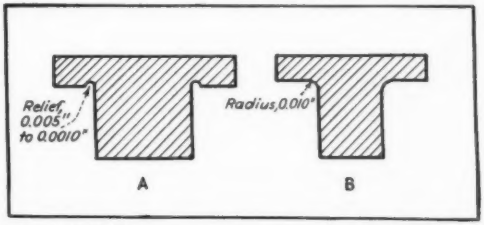

Fig. 6—Relief is necessary on parts to be coined; radii are required on unsized parts. Dimensions shown are satisfactory.

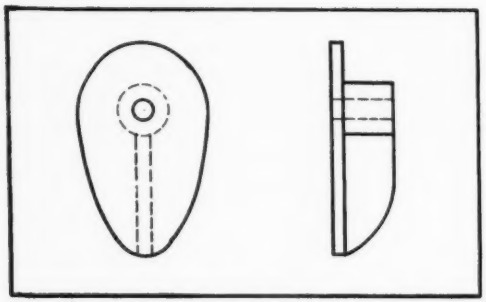

Fig. 7—Long overhanging projections must be strengthened by ribs, but ribs are not recommended for ordinary powder parts.

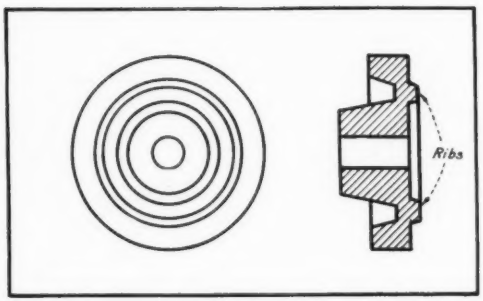

Fig. 8—Ribbing is used to equalize thickness and minimize density differentials where a part has both thick and thin sections.

ties across a part section. In some instances parts with long overhanging members such as shown in Fig. 7, cannot be ejected without breakage unless by ribbing. On others, such as illustrated in Fig. 8 ribbing is required to equalize the thickness of the section and eliminate areas of extremely high density.

BOSSES. Parts having bosses that project in two directions are difficult to produce if the part is cored. In cases

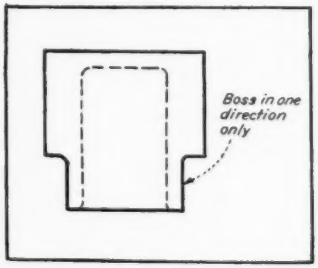

Fig. 9—To simplfy tools bosses should be projected only in one direction.

of this type, the maximum outside diameter should be extended to one end of the piece, as indicated in Fig. 9. Blind holes can be formed in these bosses without difficulty, providing that chamfers are specified at the top and bottom edges.

THREADS. Threads or circumferential grooves cannot be formed, because they prevent ejection from the mold. When threads are required, they can be machined or rolled on the part after sintering.

HOLES. Holes can be formed only in the direction of pressing. These are formed by core pins which extend from the lower punch and engage the upper punch. If the pins are long and slender they may deflect sideways under extreme pressure.

COUNTERBORES. Sharp corners should be avoided. If they are necessary, a relief of 0.005 to 0.010 in. should be used, especially if the part is sized later. This provides a recess for excess metal removed by the sizing tool and allows the tool to form a sharp clean corner.

Parts having a counterbore and an outside step taper should be proportioned as indicated in Fig. 11. Otherwise, the flow of powder is restricted during compression, which results in a section of high density at *E*. A somewhat modified form of counterboring—or coring—is shown below, Fig. 10.

SLOTS. Circumferential slots or undercuts cannot be formed, but there is no limitations on vertical slots parallel with the direction of punch action. Dovetailed slots should be designed with a small flat on the edge to eliminate feather edges on the punch. Through slots on long parts should be avoided, if the side walls are thin, as the part is likely to distort during sintering because of non-uniform density and low green strength.

It is difficult to give ratios on slot and hole dimensions relative to part length as they are dependent on the materials used as well as on the methods of processing. The key slot in the lock body part, shown in Fig. 12, is produced to dimensions without subsequent sizing. Of course, some corrections can be made by sizing, but this means another operation.

INSERTS. It is best to avoid inserts whenever possible, because they either

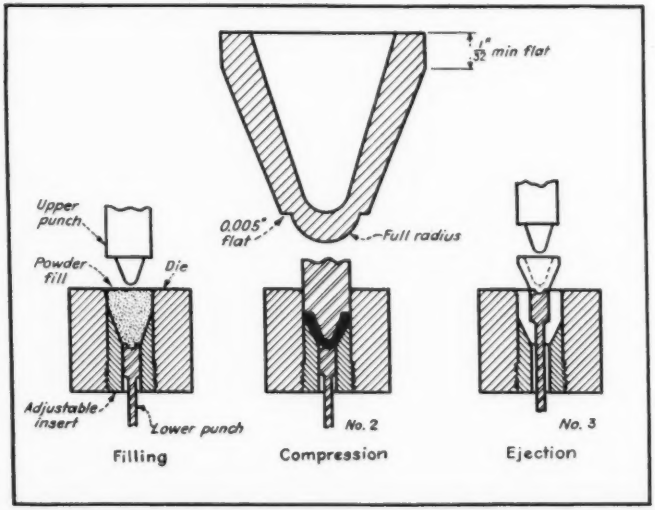

Fig. 10—The upper punch sometimes can be used for a core, as in the case of this shell.

must be manually placed in the mold prior to briquetting or else placed in a specially designed punch that releases them at the end of the downward stroke. If inserts are necessary they should be undercut, threaded, or knurled so that they do not loosen in service. In most cases, the part can be redesigned so that the insert is an integral part of the piece.

FINNED SECTIONS. Fins often are required to provide additional cooling area on parts such as radio tubes; to key the part into a mechanism; or to provide a pivot point for indexing. A finned part is shown in Fig. 13. If necessary, the fins can be made much thinner than the walls. On thin fins, the molder should be consulted.

LETTERING. Either raised or recessed lettering can be formed in the top or bottom of the part. Neither is any easier to mold than the other. In all cases, ample draft must be provided on the letters to insure easy ejection from the mold. As indicated in Fig. 14, a flat should be provided between the letter and the edge of the part.

SURFACE FINISH. The finish on a part closely duplicates the finish on the mold, and usually is superior to a ground surface. Knurling or circumferential grooving on the sides of the part will prevent ejection from the mold. Although this limitation might appear to hinder the application of powdered metal parts as inserts in plastic parts, such is not the case. Usually, the porous structure of the surface provides sufficient gripping area. If not, vertical grooves can be molded on the side walls.

Subsequent Operations

Although one of the major advantages of the powder metallurgy process is that it can be used to form intricate parts to size without requiring additional operations, it is occasionally necessary to machine, coin, harden, or plate a part. The limitations of the process, insofar as these operations are concerned, are summarized briefly in the following paragraphs:

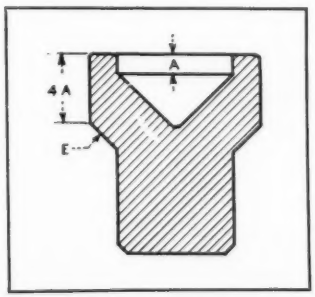

Fig. 11—Counterbore proportions required to minimize flow restrictions.

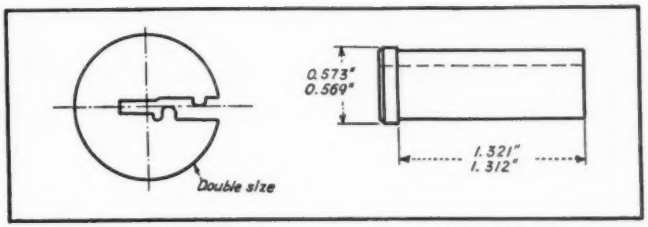

Fig. 12—Slots of this shape can be obtained without exorbitant part distortion.

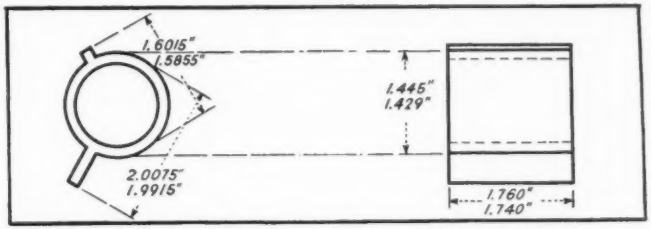

Fig. 13—Finning is one method of eliminating inserts, which are undesirable.

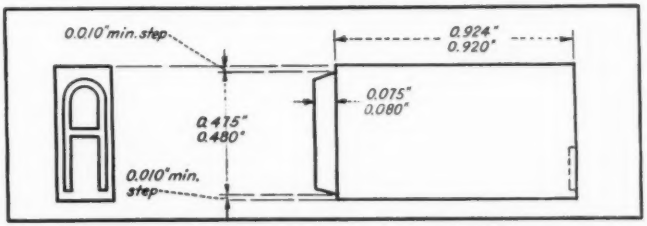

Fig. 14—Either raised or recessed lettering is practical for powdered parts.

MACHINING. Copper bearing iron alloys and mechanical bronze alloys have the best machinability. Brasses can be made machinable by close control of the powder metallurgy process. Sharp carbide tools give the best result, and a coolant is recommended if contamination of the part is not desirable.

COINING. All pressed metal alloys can be coined, but iron-copper alloys are particularly difficult, as are parts made from alloy steel powders.

HARDENING. Some iron alloys can be heat treated to give a grain hardness of 60 Rockwell C, but ordinary Rockwell readings do not give the true story due to the inherent micro-porosity of parts made by the process. Other alloys can be carburized or nitrided by conventional methods, usually in less time than required for solid metal parts. Another frequently used surface treatment is oxidation at high temperature.

FINISHING. Cadmium, zinc, chromium, silver, and gold can be electroplated on powdered metal parts. The denser the part, the better the plate. However special precautions must be taken to wash out the electrolyte, else internal corrosion occur.

Staining or coloring, with a subsequent lacquering operation to protect the surface, often is preformed. Baked enamel coatings make excellent finishes because of the penetration of the enamel into the pores.

Consideration of the previously listed limitations of the powder metallurgy process will result in better and cheaper parts. In addition, however, it should be remembered that it is difficult to predict the properties of a part from the properties of the material used to make it because of stress concentrations, density differentials, and other variables. By discussing design requirements with the fabricator, the designer often will find that certain changes can be made to increase part quality.

Air-Operated Chucking Devices

UNIVERSAL POWER CHUCK

Single rotating cylinder-piston assembly controls clamping pressure of step-cut false jaws. General usage is for external gripping of round pieces; internal gripping can be achieved by reversing the jaws. By utilizing a plug-type hand-control valve, the jaws can be eased against the work piece, thereby facilitating exact positioning.

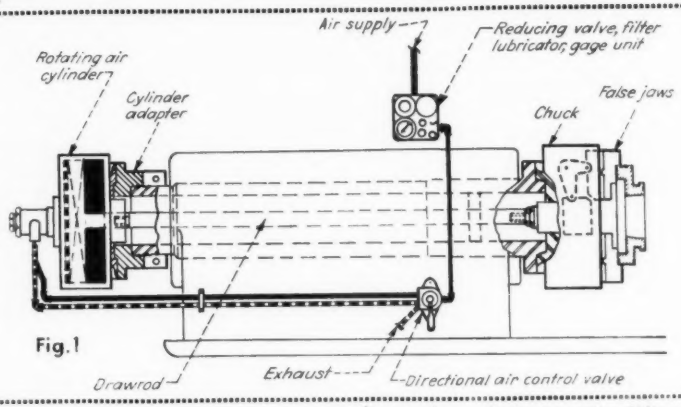

Fig. 1

COMPENSATING AIR CHUCK

Similar to Fig. 1, except tail stock center is utilized. Since floating jaws are centered automatically before full gripping pressure is applied, irregularities in the work piece up to $\frac{1}{4}$ in. can be handled. Used for "second" operation when piece must be located from a previously machined surface.

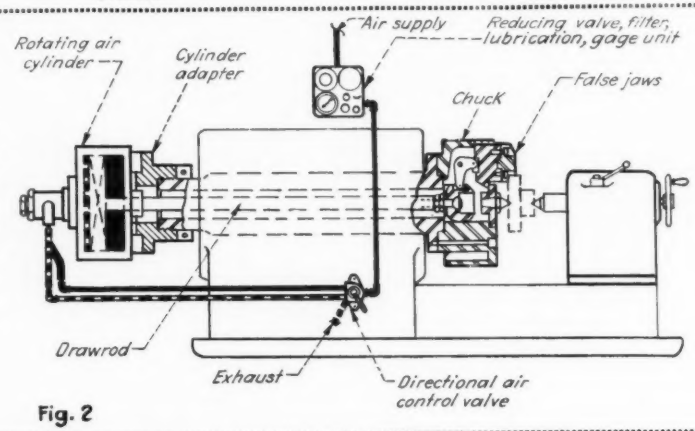

Fig. 2

AIR-OPERATED CHUCK AND TAILSTOCK

Non-rotating cylinder piston advances tailstock center, thus positioning work in chuck operated by rotating cylinder. Pressing push button A causes air-hydraulic cylinder to feed tool into work at a speed regulated by oil chamber valve. Limit switch *B* causes tool to retract. This arrangement enables one person to operate several lathes.

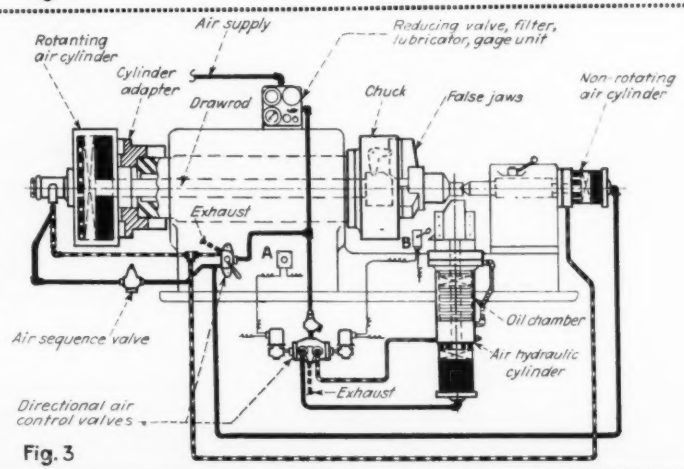

Fig. 3

for Lathe Applications

HARRY L. STEWART
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COLLET-TYPE CHUCK

Electrically operated valve controls rotating cylinder assembly that locks bar stock fed through the hollow spindle. Pressure angle of chuck affords high gripping pressure. Hollow cylinder airshaft is water cooled if surface speed is more than 400 feet per minute.

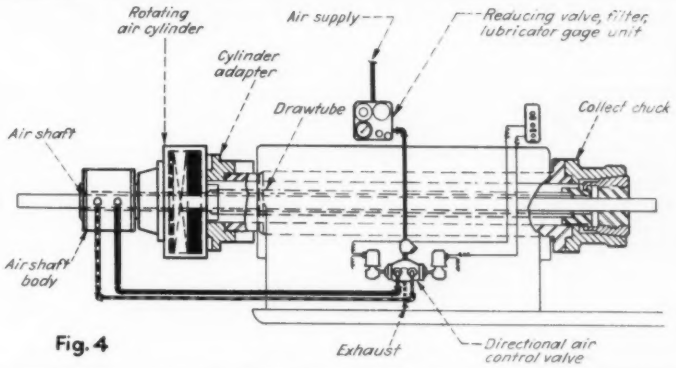

Fig. 4

MANDREL-TYPE CHUCK

Hand-operated air valves control movement of tail stock and locking of mandrel jaws. Used when high pressure gripping is desired and when work piece has long overhang. Non-rotating cylinder tailstock assembly provides fast, positive positioning of piece to be machined.

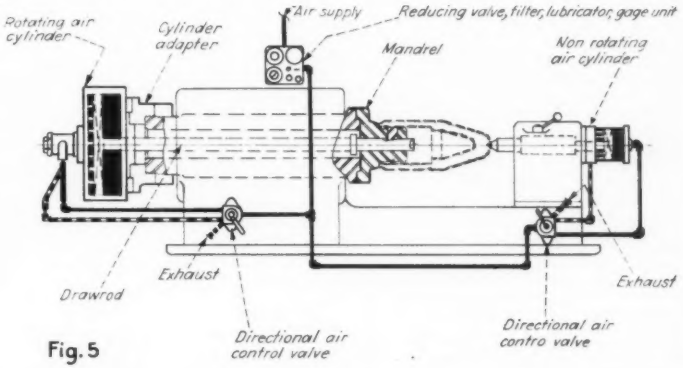

Fig. 5

DOUBLE-JAW MANDREL CHUCK

Expanding-type mandrel is equipped with an adjustable work-locator nose for positioning the work piece. Used for long pieces and on which heavy cuts are to be taken. Foot-operated control valve permits operator to use both hands for adjusting the work piece or preparing the next part for insertion.

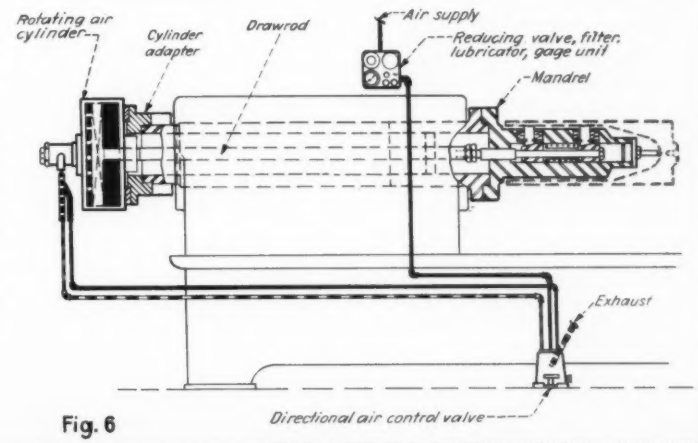

Fig. 6

Significant Stress and Failure In Static and Fatigue Loading

Effects of type and mode of loading on the significant stress as related to failure of machine parts, and the effect of abrupt changes in shape on stress distribution. Factors for geometric stress concentration, fatigue stress concentration and notch sensitivity are evaluated in terms applicable to the determination of design stresses for finite and infinite life.*

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THE FACTORS THAT AFFECT the significant strength of materials, and the magnitude of their effects, have been discussed in "Significant Strength of Steels in the Design of Machine Parts —Parts I and II," PRODUCT ENGINEERING, April 1949, page 142, and May 1949, page 124, respectively. In Part I, the significant stress was defined as the stress impressed by service loads, assembly conditions or by fabrication that is most likely to cause failure of the part. The physical significance of commonly used stress terms are shown in Fig. 1. In Fig. 2 are shown the various methods of load application and the corresponding significant stresses.

In determining significant stresses, the type of loading to which the part is subjected in service must be considered, because each type of loading induces a different type of stress. In turn, each type of stress has a different effect in causing failure.

Fundamentally, there are three types of loading: Axial, bending, and torsional. In axial loading, the direction of loading coincides with the centerline of the part. Bending loads are applied transversely to the centerline; while torsional loading results from the application of a couple in the plane normal to the centerline. For design purposes, any complex system of loading can be considered in terms of these three components.

Axial loading is the simplest and perhaps the best understood type. The common example is the standard tensile test in which a specimen is pulled in the direction of the axial centerline of the member. As a result, a stress is induced that can be estimated by multiplying the strain by the modulus of elasticity, or by dividing the load by the cross-sectional area. In axial loading, only one principal stress is induced in the member. This stress, known as the normal stress, tends to pull the particles of the material apart in an axial direction and to squeeze them together transversely. The condition is commonly referred to as the state of a uniaxial stress. Obviously with such loading, the significant stress is the normal stress in the member.

Bending loads set up a more complex stress condition. Consider a cantilever beam of uniform rectangular cross-section with the free end subjected to a bending moment. The bending action stretches the particles of the material on the top side and compresses them on the bottom side. A thin layer of particles on the upper surface of the beam is essentially subjected to an axial stress, similar to that in a tensile specimen. In the layer immediately below the upper surface, the particles are subjected to a tensile stress of a somewhat lower intensity. At each successive layer, tensile stresses become smaller until at the center of the beam they become zero. Below the center, the stress is compressive and increases as the lower surface of the beam is approached.

Because of this diminishing effect from the outside to the interior, each layer is stretched a different amount

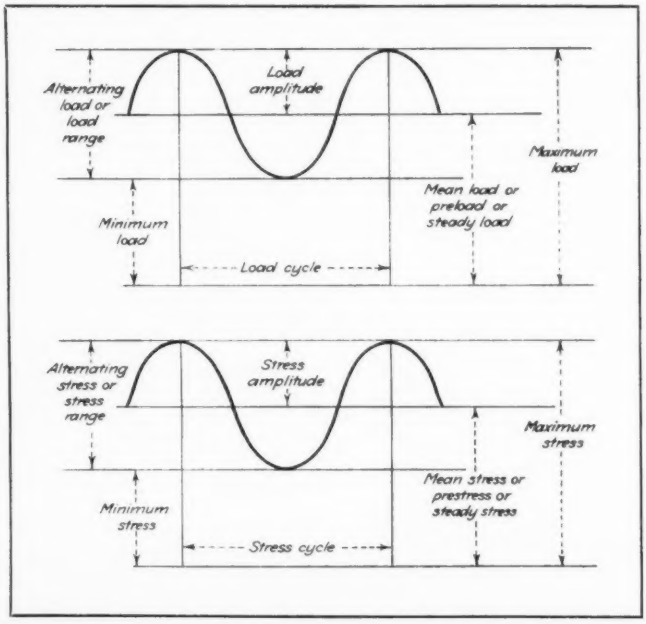


Fig. 1—Physical significance of common terms used to define applied external loads.

*The material in this article has been abstracted from the authors' manuscript "Factors of Stress and Strength," which will soon be published in book form.

and the particles of one layer tend to slip with respect to those of the neighboring layer. The tendency to slip induces a shear stress between consecutive layers; it is a maximum at the center of the uniform width beam. In bending, therefore, the significant stress could be either the tensile stress at the surface or the shear stress at the point of greatest stress difference. In most mechanical parts, the shear stress can be disregarded.

Torsional loading, like bending, induces both shear and normal stresses. The simplest example is the round bar subjected to a pure torque. During the application of the torque, a square particle on the outer surface of the member will distort into a diamond shape. Such distortion, apparently, causes two types of strains. In the planes parallel to the sides of the square, because of shear stress, the particles tend to slip with respect to each other. In the diagonal planes, because of normal stress, the particles tend to stretch along one of the diagonals and to compress along the other.

Parts made from a ductile steel generally fail because the particles slide over each other, since the resistance of steel to shear is only 0.58 of its resistance to tensile stress. This value agrees closely with the theoretical value of $1/\sqrt{3}$. Thus, in ductile steel parts the significant stress is the shear stress. Most strength of materials data are given in terms of the resistance to tensile stress. It is more convenient, therefore, to deal with shear stresses by expressing them in terms of an equivalent tensile stress, that is, a shear stress acting in a member that would have the same effect in causing failure as a tensile stress $\sqrt{3}$ times as great.

When several loads are impressed simultaneously on a member, the resistance of steel to combined stresses is a function of the energy expended in straining the steel in shear. This concept of failure, known as the Constant Energy of Distortion or the Von-Mises Hencky Theory, implies that the tendency for any system of plane stress to cause failure can be expressed in terms of an equivalent normal stress that would have the same amount of shear energy as the system of combined stress under consideration. This concept can be stated mathematically, where

S_e = equivalent normal stress
S_x = normal stress in the direction of x axis
S_y = normal stress in the direction of y axis
V_{xy} = shear stress in the xy plane

$$S_e = \sqrt{S_x^2 - S_xS_y + S_y^2 + 3V_{xy}^2} \quad (1)$$

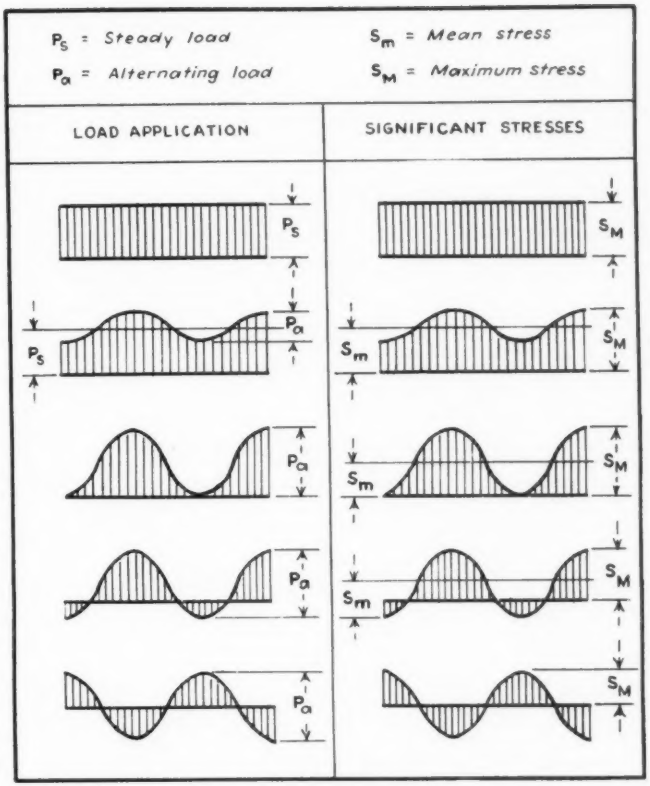


Fig. 2—Five types of load applications and corresponding significant stresses.

A rear axle drive shaft in a conventional automobile, for example, is subjected to both torsion and bending. The torsional load arises from the driving torque and causes a shear stress that is maximum at the surface. The bending load resulting from the car weight and driving force produces a normal stress that is also maximum at the surface. In applying Eq. (1) to determine the equivalent normal stress, the x coordinate is taken as the principal axis of the shaft, then the shear stress can be denoted by V_{xy}, the normal stress by S_x, and S_y can be taken as zero.

Whether a given stress can or cannot cause failure depends also on the mode of load application. The two basic modes of load applications are: Static, and fatigue. A stress that produces failure under fluctuating conditions of loading may not produce failure when the load is static.

If failure results from one or a small number of load applications, the load can be taken as static. Such failures are characterized by permanent distortion or rupture of the member as a result of stresses in excess of the yield point of the material. This type of failure can be recognized by yielding over a considerable portion of the member in the region of failure. Under static loading, the yield point should be taken as the maximum significant stress permitted.

In a limited number of designs, parts may perform satisfactorily in service even though slightly distorted. When this condition prevails, the ultimate strength rather than the yield point would be taken as the safe upper limit.

Impact loading may be considered a special case of static loading when the speed of load application affects the magnitude of load. Impact loads may be dealt with by multiplying the significant stresses for an estimated static load by a load factor or coefficient to allow for impact.

Fatigue loading is that which causes progressive failure of the member by

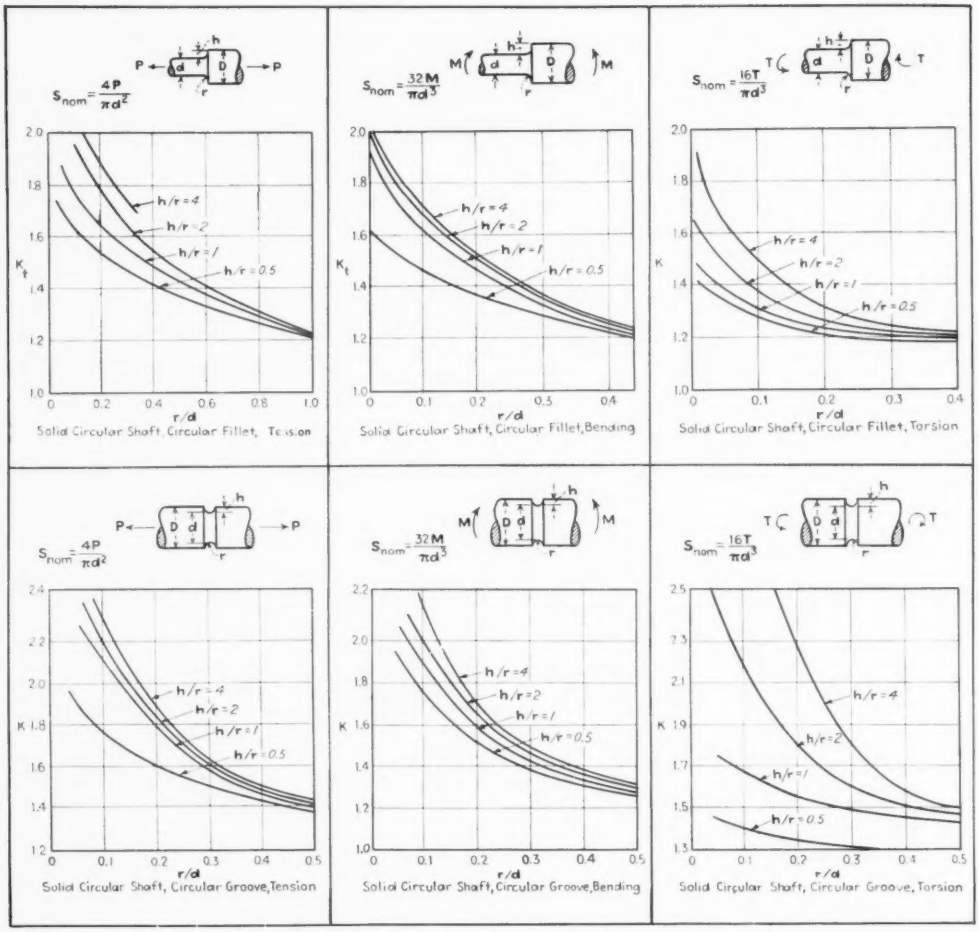


Fig. 3—Geometric theoretical stress concentration factors for solid shafts with circular fillets and with circular grooves.

repeatedly imposing stresses generally below the yield point of the material. Fatigue failures occur without perceptible yielding or necking. They originate at a localized point and progress gradually through a portion of the member. Ultimate failure occurs when the reduced cross-section can no longer withstand the load.

An example of fatigue loading is provided by a rotating railroad axle. Loaded at its ends as a simply supported overhanging beam, the top surface of the axle is stressed in tension and the bottom in compression. During each rotation, points on the axle are subject to a tensile stress when at the top and to a compressive stress when at the bottom. Thus, during each revolution the stress varies from a maximum tension to a maximum compression and back to a maximum tension. This reversal of stress will eventually cause failure by fatiguing the steel if the stress range is great enough and applied a sufficient number of times.

The range of stress and the number of times it is repeated during the life of a member are the factors that indicate the tendency of a part to fatigue under a fluctuating load. Hence, in fatigue loading the significant stress is the stress amplitude.

The most common mode of loading encountered in practice is the combination of static and fatigue loads. Such a condition of loading is met with in the design of automobile valve springs. In assembly, the valve spring is preloaded to hold the valve on the seat. During operation as the valve is opened, the spring is further loaded by additional deflection. The loading cycle ranges from a low magnitude to a higher magnitude and then back to a low magnitude. The stress resulting from this combination of loads may be resolved into a steady component, which raises or lowers the general stress level, and an alternating component, which fatigues the metal.

In combined steady and fatigue loading, the significant stresses are the steady stress and the stress amplitude, Figs. 1 and 2. The steady stress is referred to as the mean stress of the cycle. The sum of the steady stress and stress amplitude is referred to as the maximum stress.

In manufactured parts, the methods

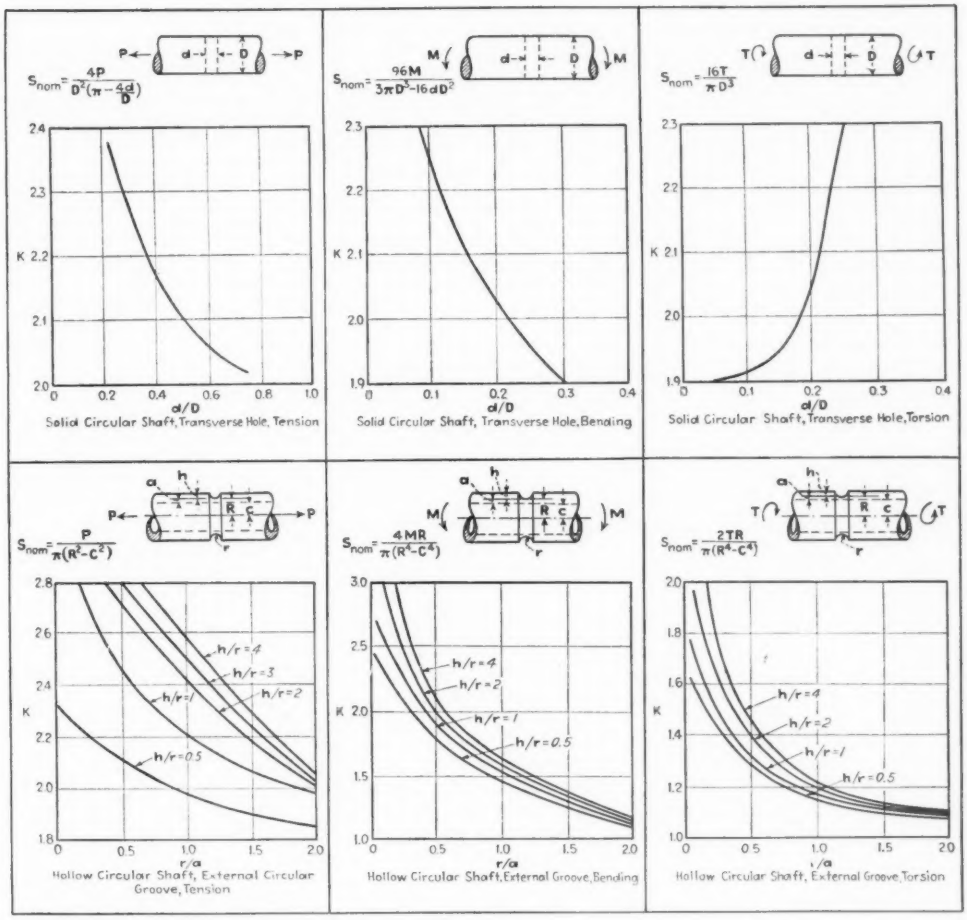


Fig. 3 (Continued)—Geometric theoretical stress concentration factors for shafts with holes and for hollow shafts with grooves.

of fabrication are of particular interest, since processes such as heat-treatment, cold straightening, and carburizing induce residual or internal stresses.

Residual stresses are of no particular importance in static loading, but they may affect the life of a member subjected to a fluctuating load. They can affect fatigue life either beneficially or detrimentally, depending upon whether they are tensile or compressive and whether they are present at or below the surface. Surface compressive stresses are associated with increased life, while surface tensile stresses are associated with decreased life.

Although the principle of addition of residual stresses to externally applied stresses is simple, in design practice it is seldom applied because sufficient data are usually lacking. These two types of stress should be combined not only at the surface of the part, but also throughout its cross-section, which implies that the magnitude and the distribution of stresses are known.

In externally applied stresses, the distribution is uniform for axial loading or it varies linearly for bending and torsion. The exact distribution of residual stresses is seldom known, thus the addition of these stresses to the external stress is frequently impossible. In addition, the effect of residual stresses on the strength of a part is much less than the effect of externally applied stresses. For steel members, residual stresses less than 25,000 psi can probably be neglected.

For these reasons, in many design problems only the externally applied stresses and the assembly stresses are taken as significant stresses, and the effect of the manufacturing processes that produce residual stresses is included in the increased or decreased fatigue strength.

Stress Concentration

The conventional equation, stress equals load divided by cross-sectional area, used for the computation of stresses arising from axial loading assumes that the stress is uniformly distributed over the cross-section of the part. This condition is approximately realized in members of constant shape or of gradually changing shape. But in the majority of designs, of necessity, abrupt changes in section exist. These

irregularities of shape are of practical importance. They cause large variations in the stress distribution in the member, as a result certain points may be stressed far more than the average stress over the entire section. Thus, any abrupt changes in shape such as fillets, holes, grooves, keyways, splines, protusions and other notches are regions of stress concentration.

Stress concentrations are not important in steel members when the loading is entirely of a static nature. Most steels have sufficient elasticity to allow localized yielding to occur, which in turn causes a readjustment of stress.

In fatigue loading, however, this localized yielding does not occur, since stresses are generally less than the yield point of the material. Consequently, a crack forms at the point of stress concentration. As the loads are repeated, the crack propagates through the member. Since most failures of machine members occur by this process, stress concentrations are important factors in determining the significant stresses.

GEOMETRIC STRESS CONCENTRATION FACTOR. The geometric theoretical stress concentration factor K_t is conventionally expressed in terms of a ratio:

$$K_t = \frac{\text{Maximum stress of the section}}{\text{Average stress of the section}} \quad (2)$$

By definition, K_t is always larger than 1 and it is a function only of the geometry of the member.

There are many methods of determining the magnitude of the stress concentration resulting from changes of geometry of the part. Of these, the most common are: The analytical method based on the elastic theory as used by C. E. Inglis, S. Timoshenko, and H. P. Neuber; and the experimental methods, such as photoelastic as used by M. M. Frocht; electrical analogy used by L. S. Jacobsen; and strain measurements used by R. E. Peterson and A. M. Wahl.

The values of K_t for various notches and discontinuities in shape have been systematized and grouped together by the authors. In Fig. 3 K_t values are given for a few types of discontinuities in circular shafts for the three common types of loading.

At points of stress concentration, a transverse stress is induced in the member because of the abrupt change in cross-section. This secondary stress tends to diminish the effect of the stress concentration as estimated on the basis of the primary stress only. The effect is especially pronounced in cylindrical members or flat surfaces with wide discontinuities as compared to the thickness of the member.

Where

μ = Poisson's ratio, 0.3 for steel
$C = \mu - \mu / K_t$
K'_t = theoretical stress concentration factor corrected for the transverse stress

the corrected theoretical concentration factor can be represented by

$$K'_t = K_t (1 - C + C^2)^{1/2} \quad (3)$$

Ordinarily the differences between K'_t and K_t do not exceed 10 percent of the latter.

FATIGUE STRESS CONCENTRATION FACTOR. Various investigators have found that the full effect of the geometric stress concentration factor is realized only in a limited number of cases. That is, the decrease in the fatigue strength resulting from the presence of a notch is frequently less than predicted by K_t. This decrease in strength can be expressed in terms of the fatigue strength concentration factor K_f (or more correctly fatigue strength reduction factor), which is defined as

$$K_f = \frac{\text{endurance limit of specimens without a notch}}{\text{endurance limit of specimens with a notch}} \quad (4)$$

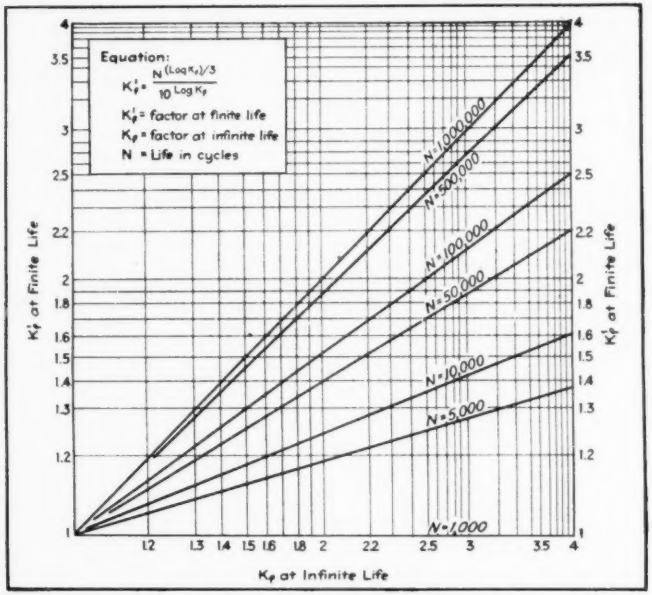


Fig. 4—Construction of diagram for correcting the fatigue concentration factor for life.

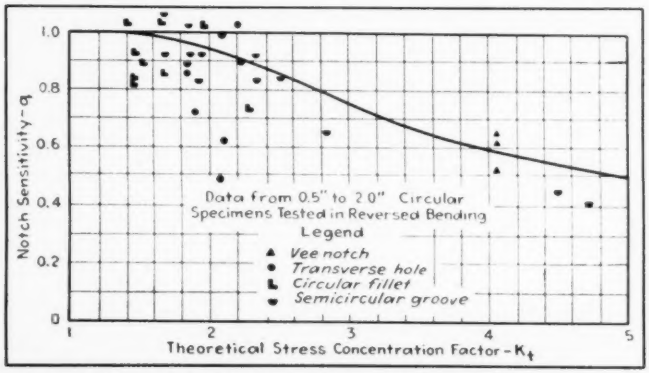


Fig. 5—Empirical relationship between notch sensitivity and the theoretical stress concentration factor for quenched and drawn steels.

In practice, the values of K_f are often of greater significance than the values of K_t, since basically the designer is more interested in the strength of the part than in its stresses.

Many designs are predicated on a "Limited life"; and for these a suitable correction should be made. Fig. 4 provides means for converting the fatigue stress concentration factors K_f for unlimited life into fatigue stress concentration factors K'_f for limited life.

NOTCH SENSITIVITY. To find a rational basis for K_f being less than K_t, R. E. Peterson evolved the principle of "sensitivity index", which he expressed as the ratio

$$q = \frac{K_f - 1}{K_t - 1} \qquad (5)$$

By definition q varies within the limits of 0 and 1. The former implies lack of sensitivity, while the latter denotes the full effect.

Notch sensitivity, thus, is a function of two quantities, K_f and K_t. The first reflects the dependence of q on the characteristics of the material, while the second the dependence of q on the geometry of the part. Fatigue tests indicate that coarse grained steels such as normalized and annealed carbon steels are usually characterized by relatively low values of q; while q for fine grain, heat-treated steels has a high value.

Since grain size is allied to heat-treatment, the effect of notch sensitivity can be effectively considered by classifying steels into two categories. The first would include quenched and drawn steels that usually have fine grains and high notch sensitivity, while the second refers to annealed steels that have coarse grains and a low sensitivity. Quenched and drawn is meant to include any steel that is given heat-treatment to increase its hardness above that of the as-received state. Annealing is meant to include normalizing and all other processes that use a slow cool, with the exception of tempering. Approximately 200 BHN is the dividing line between quenched and drawn steels, thus defined, and the annealed steels.

The empirical relationship between notch sensitivity q and the theoretical stress concentration factor K_t is shown in Fig. 5 for quenched and drawn steels and in Fig. 6 for annealed steels. The points on the plots are test data taken from authoritative literature pertaining to fatigue tests of V-notch, semi-circular groove, transverse hole and filleted specimens.

The practical significance of these curves is that for any known value of K_t the fatigue stress concentration factor K_f can be determined with the aid of Eq. (5) rearranged as follows:

$$K_f = 1 + q\,(K_t - 1) \qquad (6)$$

For convenient reference Eq (5) is plotted in Fig. 7. For the majority of notches the theoretical stress concentration factor K_t is less than 5. For this value of K_t the fatigue stress concentration factor K_f is 2.5 for annealed steels, and 3 for quenched and drawn. These values of K_f can therefore be accepted as the approximate upper limits.

This condition can be illustrated by the following example. It has been reported that in threads the theoretical stress concentration factor K_t reaches a value of 11. This statement does not mean that the presence of a thread results in an eleven-fold, or 91 percent, reduction in the strength of a threaded member. It will be noted from Fig. 7 that the maximum value of K is 2.5 for annealed steels and 3 for quenched and drawn. Therefore, the reduction in strength resulting from the presence of threads will be 60 percent for quenched and drawn.

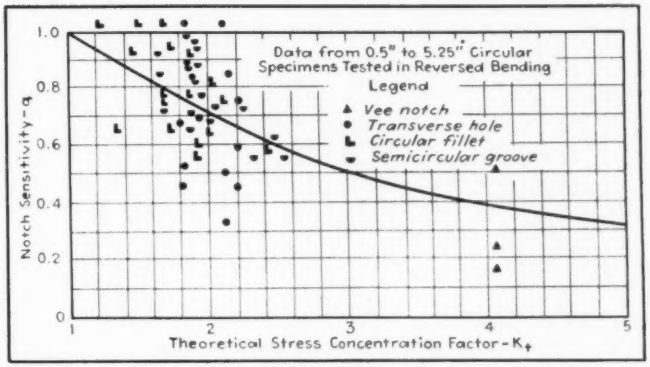


Fig. 6—Empirical relationship between notch sensitivity and the theoretical stress concentration factor for annealed steels.

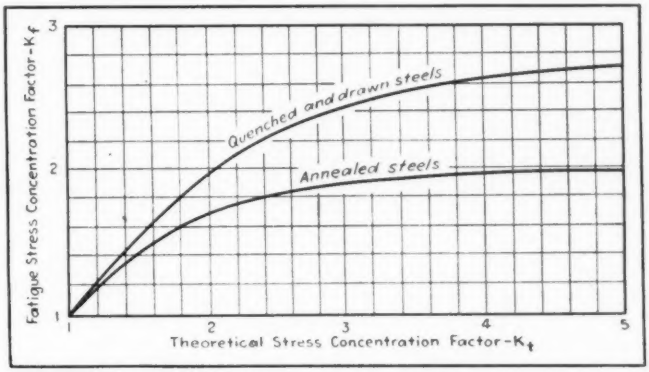


Fig. 7—Relationship between the fatigue and the theoretical stress concentration factors.

EFFECT ON SIGNIFICANT STRESSES. As has been stated before, stress concentration affects detrimentally the fatigue strength of the member and not its static strength. In determining significant stresses, therefore, stress concentration should be applied to the alternating component of stress and not to the static component.

Since the significant stresses are the maximum stress and the mean stress of the cycle, the effect of stress concentration is to leave the mean stress unchanged and to increase the alternating component, thereby increasing the maximum stress.

EDITOR'S NOTE: The next article in this series will discuss equality of strength and stress in the design of machine parts, and will evaluate a design factor for predicting a satisfactory balance between stress and strength in economical design.

Fig. 1—The unusual force-deflection relationship of the negative spring is demonstrated in the pictures above. The spring gradient is such that the force exerted decreases one-third for the 2 in. extension shown here.

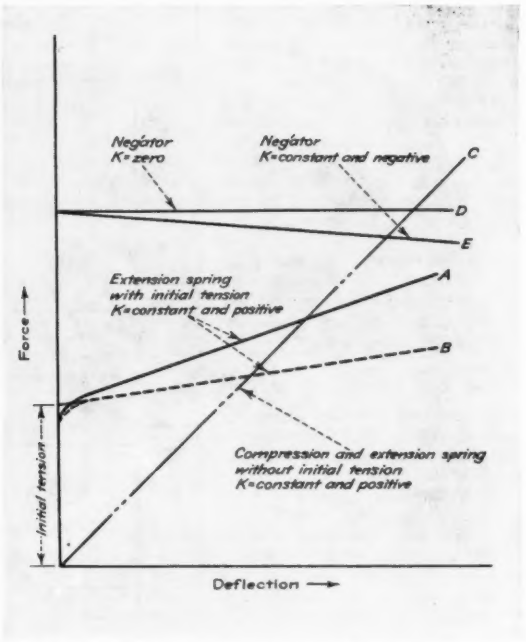


Fig. 2—Spring gradients for compression and extension springs compared with those for two variations of the new type of elastic member. Similar elastic members can be made with constant, increasing, or even varying force-deflection characteristics.

The Negative Spring—A Basic

Designers who work with spring products have long wished for the seeming impossibility of elastic members with flat or negative spring gradients, having constant or decreasing spring force with increased deflection. A new spring device, the Neg'ator, has this and several other unusual properties that should enable simple solutions to many mechanism problems.

W. J. COOK and P. C. CLARKE
Hunter Spring Company

THE DESIRE for elastic members with zero or negative gradients most commonly arises from the need for constant loading of mechanisms. To achieve constant loading with conventional extension, compression, torsion or spiral springs, having normally positive gradients, designers have had three possible methods: (1) Replace springs with dead weights, (2) cause springs to act through intricate cam or lever systems, or (3) specify extra-long, extra-limber springs with gradients only approximating flatness.

In Fig. 2, Curve *A* represents the force-deflection characteristic of a normal extension spring wound with initial tension. Curve *B* represents the spring maker's effort to approach the designer's need for a zero gradient. Even in unusual cases, where force requirements are low or it is possible to provide for springs that are long with respect to the range of useful deflection, it is rarely possible to obtain more than an approximation of flatness in the force-deflection characteristic.

Just recently, however, there has been invented a new type of prestressed coiled component (trade-named the "Neg'ator", and covered by patent applications by the Hunter Spring Co., Lansdale, Pa.) which is characterized by five remarkable properties:

A. Flat or receding force-deflection characteristics. See Fig. 2, curves *D* and *E*.

B. Enormous expandability and range of action. Usable deflections as high as 30 to 50 times the original dimensions of the unloaded spring. This contrasts with the usual extension spring which expands only ½ to 2 times its original length.

C. The ability to act without losses or inaccuracies around corners and through small openings, and with the same freedom as non-elastic bands or cables.

D. High initial force, even up to maximum rating, at initial deflection.

E. The ability to store and deliver

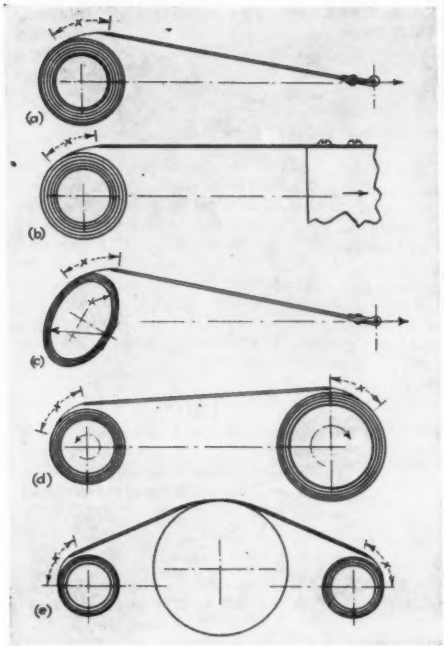


Fig. 3—Five ways of using the new spring device. The first three methods shown are for linear deflections; the others are for use with angular deflections, where the opposing forces are torques on shafts, pins, or drums.

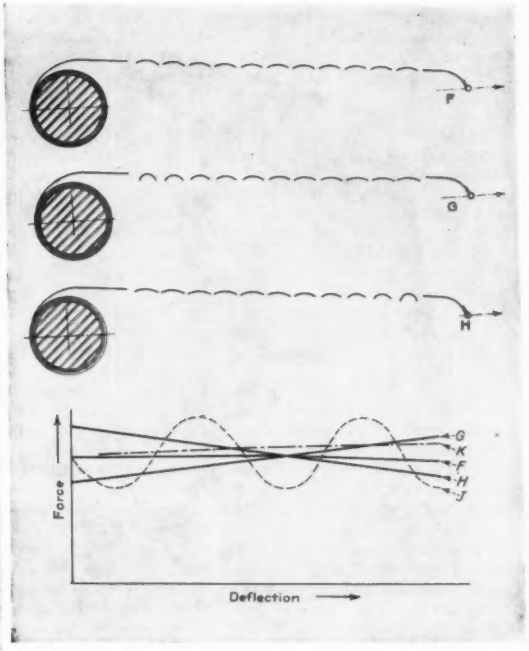


Fig. 4—Force-deflection characteristic of any Neg'ator is determined by the amount of prestressing in each incremental length. Springs *F*, *G*, and *H* show the natural radii theoretically assumed by increments of springs stressed to give different types of gradients.

New Elastic Member

approximately twice as much energy as an ordinary spiral or power spring occupying the same space.

How the Neg'ator Works

The Neg'ator is distinguished from previously known springs in that the elastic characteristic of each increment of length is used sequentially from one end to the other, rather than all at once.

Briefly, the mechanism is a tight coil of flat material which is progressively unwound throughout the range of action. The material is prestressed in manufacture so that it possesses a strong natural curvature, and force must be exerted to straighten it. In use, either (1) the free outer end of coil may be pulled, as at *a*, *b* and *c*, in Fig. 3, the yet-unwound coil being free to rotate about its natural axis; or (2) the opposite ends of the spring may both be coiled about shafts, spools, spindles, pins or drums, as at *d* and *e* in Fig. 3. In these latter applications the opposing forces are torques.

Throughout its entire length the device is so highly prestressed that when it forms a natural coil the turns lie tightly upon each other and the resultant coil is solid. The coiling torque, which opposes the uncoiling pull, is developed only by that section of the spring that is being straightened as it is drawn off the tight coil. This working region of a Neg'ator at any instant is indicated in Fig. 3 by the zone marked "x".

It is easy to understand how this spring can have a flat, a receding or a rising force-deflection characteristic if one imagines the coil cut into many incremental lengths. At the top of Fig. 4 are shown, diagrammatically, three different types of Neg'ators that have been cut into incremental lengths. Each increment is assuming its relaxed shape with zero stored energy, and each takes its natural radius of curvature. The spring shown at *F* has been prestressed evenly along its full length so that each incremental section has the same natural radius of curvature. Accordingly, the force-deflection characteristic is horizontal, as illustrated. The spring shown at *G* has been so prestressed that the right-hand end, forming the outer coil and comprising the first incremental lengths to be straightened, possesses a natural radius of curvature larger than that of the left-hand end, which is the last to be unwound. Accordingly, a rising force-deflection characteristic is obtained. Finally, the spring shown at *H* is such that the first material to be straightened, the right-hand end, possesses a smaller natural radius of curvature than the last material to be straightened. Therefore, a falling force-deflection characteristic—a negative gradient—is obtained.

Thus it can be seen that the different elastic characteristics of these three springs lies in the work required to straighten the incremental lengths in sequence as they pass through the zone "x", Fig. 3, during uncoiling.

The distinctions between the negative spring, the normal power, and

the normal spiral spring, all shown in Fig. 5, are important.

In its normal, unrestrained position, the stock of the Neg'ator forms a solid coil; the stock of the power spring lies out flat or nearly so; and the stock of spiral spring lies in the illustrated coiled position with ample free space between successive layers. If the outer end of either a spiral or power spring is held and a torque applied on the shaft holding the inner end, the spring will wind on the shaft. On the other hand, the negative spring is already tightly wound on its shaft because its natural radius of curvature at any point is less than that of the shaft. If the outer end is held, it can be wound no further.

Perhaps the most significant distinction is that in a power or spiral spring the entire length of the stock that is not physically restrained by contact with other turns acts like a long bent beam to produce torque. In the Neg'ator, only that stock in the partially straightened zone produces torque.

Obviously, the coil radius from which any incremental length of the negative spring is uncoiled affects the force it exerts. The limiting case, which is the greatest force, occurs when a section is unwound from its natural radius of curvature. If the spool or drum on which the spring is wound is of larger radius than the natural radius, a fraction of the straightening work already has been done by mechanical restraint; thus, less force is required to finish the job.

The larger the spool, the less force the spring exerts, other factors being equal. Should, for example, the spool be elliptical, as in Fig. 3c, the radius at the point of uncoiling would change cyclically. Then such sinusoidal force-deflection characteristics as shown in *J*, Fig. 4, become possible.

As a further peculiarity, consider the arrangements in Fig. 3 at *d* and *e*, where a Neg'ator is coiled on two spools. Since it takes more work to uncoil the negative spring from a smaller spool than from a larger spool, the normal tendency on two free turning spools *d* in Fig. 3, would be for the unrestrained spring to run from the larger spool at the right onto the smaller spool at the left. When the spools are of the same diameter, *e* in Fig. 3, coiling torques are balanced, and the system is one of simple power and motion transmission, not unlike a pulley-belt arrangement with only one leg.

Consider the effect of a gradual change of the radius of a coil with the normal winding or unwinding of successive coil turns. If a uniformly prestressed spring, of the type diagrammed at *F* in Fig. 4, were made of relatively heavy stock and uncoiled from a spool of relatively small radius, the result would be a gently rising force-deflection characteristic as shown at *K*. Successive increments of length would be straightened from successively smaller radii.

The photographs reproduced in the headpiece and in Figs. 6, 7 and 8, suggest the degree to which this spring device possesses great expandability and range of action, and show how it can act around corners and through small openings.

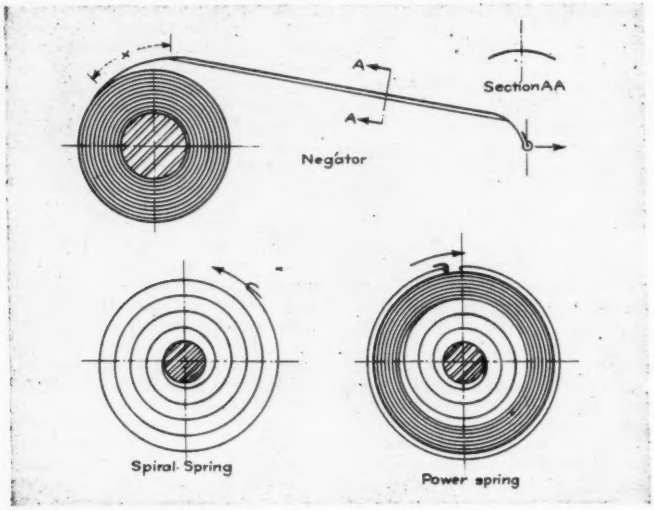


Fig. 5—The distinction between spiral and power springs, and the negative spring is shown above. With the latter, no mechanical restraint is used, yet the coils lie tightly on one another, and on the shaft. This may not be apparent from the drawing.

Basic Design Formula

The basic relationship between the external force applied to a Neg'ator and its internal reaction, is developed by equating the external work done by extension through an incremental length to the energy stored in the system by straightening an equivalent incremental length (of natural radius of curvature, R_n) from a coiled radius, R_1. The following formula is a close approximation:

$$P = \frac{EI}{2}\left[\frac{1}{R_n^2} - \left(\frac{1}{R_n} - \frac{1}{R_1}\right)^2\right]$$

Where

P = Force applied, lb
E = Modulus of elasticity
I = Moment of inertia of section of stock
$= \frac{bt^3}{12}$, in.^{4}
b = width of stock, in.
t = thickness of stock, in.
R_n = Natural radius of curvature, in.
R_1 = Radius of mounting (spool, shaft, drum), in.

If the spring is already flat, R_1 equals ∞, the term in brackets reduces to zero. If the spring is unwound from its own natural radius, R_1 equals R_n, the term within the brackets reduces to $1/R_n^2$.

The calculated force, P, based on the formula above, is a few percent greater than the actual extending force measured by test. The difference is caused by the energy consumed when a section of the spring, approaching flatness, snaps into the lateral arch, or camber, characterizing the fully straightened lengths. This arching is noticeable in the pictures and drawings. For critical designs, allowance may have to be made for this error in the simplified formula.

Indicated Uses

The use of this spring device is seemingly limited only by the imagination.

Already basic fields of application have appeared. They are: (1) as a spring (extension or compression); (2) as a self-adjusting clamp, clip, or wrapping; (3) as a vernier force compensator; (4) as a transducer for converting energy from one system to another; (5) as an automatic coiling device; (6) as a friction band; (7) as a telescopic tube form; and (8) as a means of power or motion transmission.

The flat or receding force character-

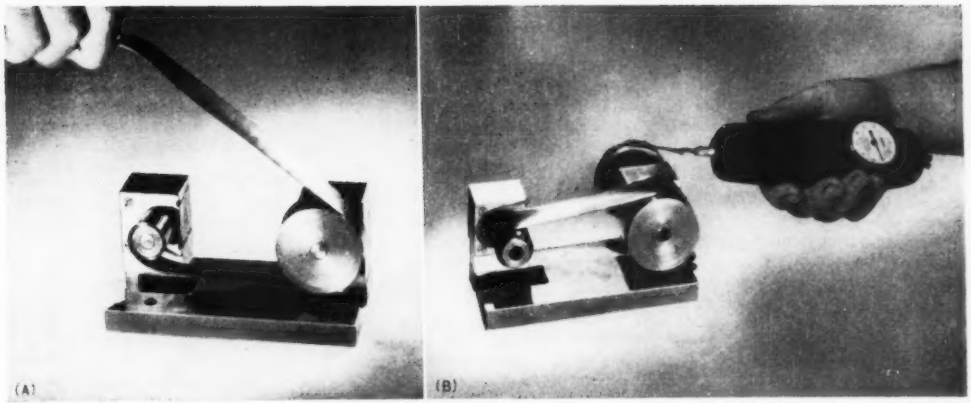


Fig. 6—(A) The ability of the new device to act around corners, without losses or inaccuracies, is unique in spring design. Here is a negative spring acting at approximately 135 deg from its original line of extension. (B) If a negative spring is wound on two spools of different radii, as shown above, it will run to the smaller spool unless restrained by an external force.

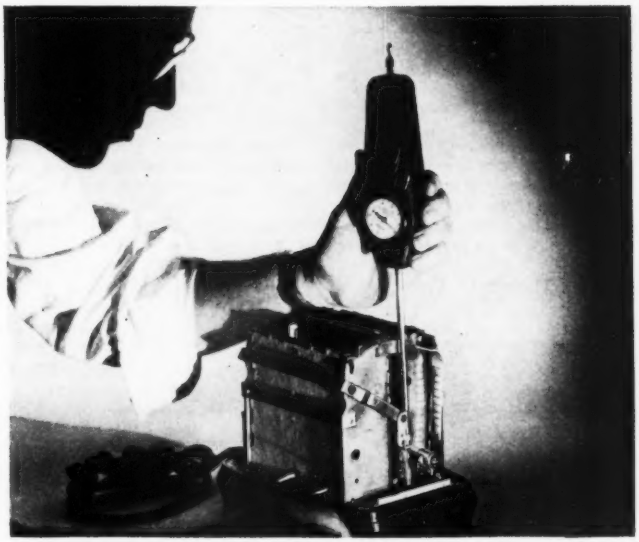


Fig. 7—Studying a constant-force Neg'ator installed at the right side of the toaster. The availability of constant spring loads with increasing deflection enables the replacement of dead weights, dash pots, cams and lever systems now used to maintain constant forces. The possibility of varying the force throughout the range of deflections opens up a whole new world of applications. Furthermore, there should be many uses in the fields of control, instrumentation, and automatic coiling.

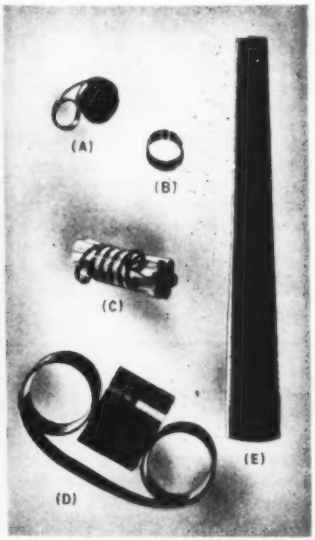


Fig. 8—Five basic uses for the new spring mechanism. (A) self-winding tapes; (B) a clip, formed to a full 357 deg from stainless steel; (C) a wrapping; (D) clamp holding two ½-lb steel disks; (E) telescopic tube form.

istic and the great extendability suggest uses as a spring where constant loads are required. This is wherever levers, pulleys and dead weights are currently used or for replacement of, or in conjunction with, torsian, spiral, normal extension, compression, or power springs.

An example of a desirable application for a truly negative gradient would be in opening and closing devices. Here it is desirable to start the opening with minimum force but to assure greater restraint in the open position. A flat force-deflection characteristic would make a highly desirable means of replacing counter weights and sash weights. Many interesting spring applications should result from the small cubical space required by a negative spring in its coiled state, and its ability to act around pulleys.

As a clamp the mechanism promises many immediate applications in replacement of screw-clamp devices. The simplest means is to permit the two ends to coil freely so that the pressure between the opposed coils hold the clamped object, Fig. 8. The pressure between the two coils will be

constant, regardless of thickness of the object held, if the spring gradient is zero. Possible applications range from industrial vises and clamps for holding work-pieces in position during brazing, gluing or other processing, to such everyday objects as the grips on bookends, jewelry, broom holders and display fixtures.

This spring mechanism also can provide clipping pressures and full-circumference binding not heretofore available without costly heat treatments and dimensional difficulties. Furthermore, it is now practicable to make these clips of many materials, such as stainless steel and phosphor-bronze. A negative spring clip is usually one coil of 360 deg, and it requires no heat treatment (see foreground of Fig. 8).

The flexibility and tape-like character of this spring make it ideal as a wrapping for such uses as holding insulation on pipes, sheathing or reinforcing cable and hose, and binding bundles of prismatic or columnar parts. Medical men are considering splinting with helical Neg'ators. It is even conceivable that narrow thin-gage springs, spooled as metal tapes with uniform natural curvature, could be merchandised for office and home wrapping use.

As a transducer for converting mechanical energy to electric modulation or to magnetic modulation, the negative spring has possibilities because of the "solid" nature of the free coil. Electrical engineers are considering the device as a variable resistor, the modulation of which is evenly continuous, and not by incremental steps. The coil form also makes it useful for changing the amount of laminated core iron in a magnetic field. Designers of instruments, control apparatus and electrical circuits may find possible applications using these springs made from insulated and plated stock. As a potentiometer slidwire, in arrangements similar to Fig. 3d and 3e, application has been started.

For vernier adjustment of a force member, the gage of the stock of which a Neg'ator is made can be utilized. As was discussed for Curve *K*, the force exerted by this device is minutely adjustable by gradually increasing the radius of curvature of the coil by the mere act of laying turn upon turn. Applications for delicate manual or automatic force compensation are indicated.

Simplification of mechanisms for the reeling of cables and bands are possible by using the spring as a self-winding tape, which automatically coils itself tightly. Designs of sound recording and electronic calculating equipment may be affected. New automatic take-up mechanisms suggest themselves.

As a friction element, the negative spring should simplify braking arrangements. A simple negative spring clip is an automatic friction band that exerts uniform pressure around circular drums. It is no longer necessary in designing braking devices to think only of rigid shoes or flexible bands which are externally pressed on drums or shafts by springs-and-lever systems. The braking pressure can now be inherent in the brake band member.

A speculation about friction applications is the possibility of being able to turn the shaft inside the spring coil in one direction but not in the other, the free end of the coil being fixed. It can thus be used, in effect, as a ratchet.

Because the negative spring offers active pressure of coil on coil, telescopic tube forms may be developed for new functions. It should be practical to control such attributes as light-tightness, leak-proofness and lateral rigidity in this device.

Finally, to transmit power or motion, designers can consider the spring as: (1) a means of translating linear into circular motion or vice versa, and (2) as a pulley-belt with a single leg and automatic take-up features. Applications to circuit tuning (see Fig. 3e) augur the elimination of take-up springs and flexible bands with their replacement problems. The center drum could be for gross adjustment, and either of the smaller shafts for vernier adjustment.

There is much to be done in devising end-grips, shafting arrangements, housings, supports, limit stops and other such elements concomitant to practical engineering use. But it seems clear, even at this early stage, that a new basic type of mechanical device has appeared; and by ingenious application many significant design improvements should be possible.

Bi-Plastic Hygrometer Is Both Inexpensive and Accurate

A NEW ECONOMICAL bi-plastic humidity-sensitive element, called the Humidial, is so simple that it can be manufactured to a uniformity that permits its use with an accurate hygrometer scale. This characteristic is not true of existing hygrometers that are based on gold beater's skin and human hair, the composition and dimensions of which vary over wide ranges.

The better direct-reading hygrometers incorporating human hairs and various types of gut are sensitive but require expensive internal mechanisms that place them out of the popular price range. Cheaper hygrometers are usually made of paper-metal coils, but these elements lack the sensitivity, accuracy and temperature correction found in the more expensive hygrometers. Agreement with readings from a sling psychrometer is very close.

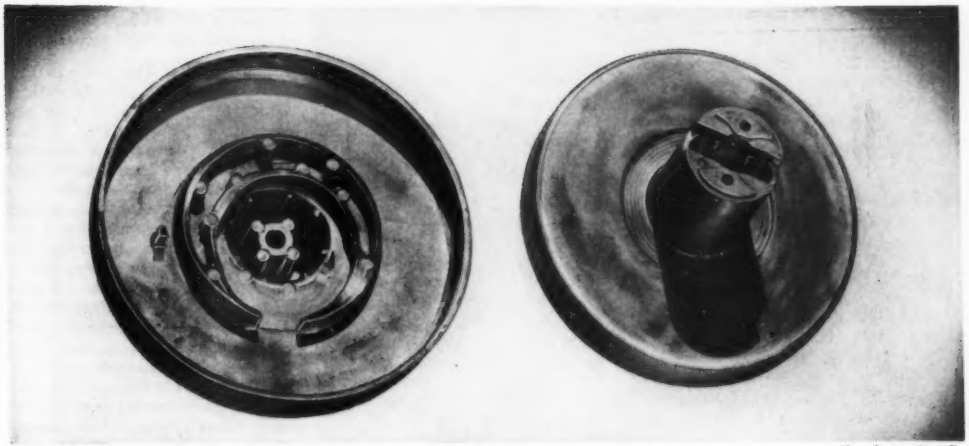
The element consists of two thin plastic sheets bonded together. One plastic is polystyrene that is dimensionally stable with changes in relative humidity; the other is a specially formulated and cured cellulose plastic that varies dimensionally in accordance with moisture absorption. As a result, the laminated pointer formed will attain a different curvature for each relative humidity. As both plastics are stable at very low humidities and expand almost uniformly with temperature changes, little correction of readings is required.

Recalibration is necessary at infrequent intervals to compensate for slight drift that amounts to about 5 percent per year under average conditions. Adjustment is easily made by rotating the rubber mount for the element with a pair of tweezers.

A single pointer exerts very little torque, but the amount of twist can be increased by mounting units in parallel without loss of sensitivity or accuracy. No attempt has been made to use the pointers in recording or controlling mechanisms, but an economical electrical follow-up device adapted to "sense" the pointer movements could prove useful.

The meter has promise in packaging applications where other hygrometers are either too expensive or become inoperative at low humidities. Competition will be with silica gel indicators that depend on a change of color and are usually one-shot devices.

Retail price of each instrument is $1.50. The manufacturer is the Humidial Company, 1536 Connecticut Ave., N. W., Washington 6, District of Columbia.



New Jersey Zinc Co.

SYNTHETIC ORGANIC FINISH simulates brushed brass plate on zinc die cast turntable of the new RCA 45 rpm record player.

How to Specify Organic Finishes

An intelligent selection of properly designed organic coatings should be based on the special requirements of the material and product to be protected. Synthetic resin finishes find widest use on heavy duty electrical, mechanical, and chemical equipment.

ALLEN L. ALEXANDER
Naval Research Laboratory

INADEQUATE SPECIFICATIONS permit early failure in performance of organic coatings. For example, steel members in contact with moisture have been "protected" by merely specifying the application of a film of red lead primer, without designating the vehicle that carries the pigment. Linseed oil pigmented with red lead will perform adequately under normal atmospheric conditions but films prepared from it disintegrate rapidly when in contact with moisture. Thus, there is a need for careful control of the vehicle under a variety of conditions.

Types of Organic Coatings

A classification of finishes, based on both vehicle and pigment types, is of value in selecting the proper finish:

VARNISHES. Varnish is usually considered to be a combination of oil and fortifying resin, either natural or synthetic. The resin may be in chemical combination with the oil. The combination is thinned with suitable solvents; the amount and type of thinning regulates such properties as initial drying time; viscosity for spray, brush or dip application; and film thickness. Varnish is used as a clear (unpigmented) composition and dries in air by oxidation of the oil; this requires longer drying periods than coatings that dry simply by solvent evaporation. The proportions of oil and resin can vary considerably; the number of gallons of oil per 100 lb of resin is defined as the "length" of the varnish.

PAINTS. A paint is a dispersion of pigments in a drying oil, such as linseed oil, and thinned to proper consistency for application. Increased use of fortifying resins in oil-base paints has practically removed any clear distinction from "air-drying" enamels.

ENAMELS. An enamel has been considered a pigmented varnish. Since the use of resins in paints has become so general, the term enamel has come to apply more appropriately to a group of fast-drying or baking resin-base finishes.

LACQUERS. This term was originally applied to a solution of natural resins dissolved in appropriate solvents that dry rapidly by evaporation of the solvent. The definition includes both pigmented and non-pigmented compositions. More recently, the term describes any air drying and some baking type compositions, based on nitrocellulose or other cellulosic resins.

SHELLAC. Shellac is considered a "special" lacquer. Normally available shellac, either orange or white, consists of a solution of lac, a natural gum, in alcohol. It is commonly supplied in a ratio of 4 or 5 lb per gallon of alcoholic solution, and dries rapidly to a hard, non-tacky durable film.

BITUMINOUS COATINGS. Asphalts or pitches accumulate as residues from the distillation of crude petroleum in semi-solid or solid form. They are used by melting and applying hot, or by dispersion in a solvent and brush applications. They have high resistance to water and chemicals.

RUBBER AND RUBBER-LIKE COATINGS. These materials might be considered conservatively as special "enamels". They consist of solutions of natural rubber, chlorinated rubber, and some of the synthetics, such as the butadiene derivatives and polysulfide rubbers. They find use on equipment that contact acids, alkalies and other highly corrosive chemicals.

Pigments

When organic coatings are intended purely for decorative purposes, pigments may be selected largely on the

ABRASIVE RESISTANCE of airplane propeller finishes is tested in this laboratory apparatus. A mixture of sifted sand and water is blown onto the specimens, with the aid of compressed air. Effect on the coating is shown in the close-up view of the rotor, containing the test panels. Specifications consist of a number of cycles before failure.

basis of color, although consideration must be given to such properties as light-fastness, chalking tendency and solubility. In industrial finishing, however, the chief problems are protection of metallic parts from corrosive deterioration, or the protection of such materials as wood from the penetration of moisture. In addition to choosing the most appropriate vehicle, selection of the optimum corrosion-inhibiting pigment is essential. Among the most commonly used pigments are the following, based largely on derivatives of lead and zinc:

Lead	Zinc
Red Lead	Zinc Chromate
Basic Lead Sulphate	Zinc Tetroxy Chromate
White Basic Lead Carbonate	Zinc Oxide
Lead Chromate	Zinc Dust

Iron oxide might be added to this list. However, other less widely used pigments such as barium, strontium and calcium chromates are valuable in retarding corrosion of magnesium and aluminum and their alloys.

In addition to these anticorrosive pigments, a number of pigments are available for other specialized requirements. Activated zinc sulfide is used in luminescent coatings for decorative and functional purposes. Chromium oxide pigments are used in infra-red reflecting paints, in dark colors, to reflect a maximum of incident sunlight energy in the longer wavelengths. A typical application is on fuel storage tanks, to maintain low temperatures.

Resin Types

The ever increasing number of synthetic resins and oils provides flexibility in designing coatings to protect specific products and materials. For finishing industrial products, enamels, lacquers and varnishes containing synthetic resins find widest application.

ALKYD RESINS. This group of resins, and the phenolics, are the most versatile group of materials from which specialized finishes are produced. Chemically, these resins are classed as polyesters and are usually formed by the interaction of phthalic anhydride and glycerine, with a limited number of drying oils. These resins can be modified to produce films varying from a hard brittle type to a soft elastic material. They are characterized partly by their excellent durability, and find wide application in finishes for automobiles, trucks, farm equipment and objects requiring roller coating and decorative wrinkle or crackle finishes. They should be avoided, however, where prolonged exposure to moisture or to alkaline environment is anticipated; under these conditions, rapid deterioration of the film results.

PHENOLIC RESINS. This class of resins can be modified as finishing ingredients into two types: (a) Thermoplastic resins that remain permanently fusible to heat; and (b) thermosetting resins which when heated form permanently hard and insoluble resins. Phenolics are often used as fortifying agents for drying oils in the preparation of paints. They are characterized by especially high resistance to moisture, chemical resistance, heat resistance and good durability. Certain types, known as "dispersion" resins, are used in extremely fast-drying films. They are applied in can and drum linings, electrical insulation and spar varnishes, when color stability and high flexibility are important. Baked films, made of the thermosetting types, are especially chemical-resistant.

UREA RESINS. Urea resins are thermosetting and when baked, form a hard insoluble film that is applied on such products as refrigerators and washing machines. To attain flexibility, these resins are modified with an alkyd resin, which also cures during baking. Finishes prepared from these resins are noted principally for their hardness, clarity, and color retention during baking and aging. (See "Evaluating the Ideal Instrument Finish", p. 134, May 1948, PRODUCT ENGINEERING.)

MELAMINE RESINS. The melamines are similar to the ureas in many of their properties, and have the same kinds of applications. They are used to improve drying speed, water resistance and flexibility.

ACRYLIC RESINS. These resins are available in a wide variety of proper-

ties, including good flexibility, extreme clarity and excellent resistance to light. They can be used both clear and pigmented, and are resistant to water, acids, alkalies and mineral or vegetable oils. In this respect they are superior to some phenolics.

CELLULOSE DERIVATIVES. Derivatives of cellulose are the basis of most fast-drying finishes that dry by solvent evaporation. The most commonly used cellulosics are cellulose nitrate, cellulose acetate and cellulose ethers (ethyl cellulose), in approximate order of importance. Cellulose nitrate is the primary constituent of the "pyroxylin" lacquers, which are usually modified by adding varying amounts of other resins, particularly the alkyds. However, it is highly inflammable and discolors appreciably on aging. Both of these disadvantages are overcome by using cellulose acetate, which is however, difficultly soluble. Cellulose acetate is not used in lacquers to the same extent as cellulose nitrate; its uses are often limited to applications where non-flammability is essential.

Ethyl cellulose is finding increasing use as a constituent of clear lacquers, usually in combination with other resins. Lacquers derived from cellulose compounds are quite susceptible to penetration by moisture, and are quite brittle, requiring that they be considerably modified with more flexible resins. In combination with other resins, cellulose derivatives shorten drying time, improve hardness and make possible rapid finishing.

MISCELLANEOUS RESINS. The silicones, although not as commonly used as those already described, are characterized by extreme hardness and resistance to high temperatures. They are recommended for electrical insulation and for finishes required to withstand prolonged elevated temperatures and certain types of chemicals.

The vinyl resins, including polyvinyl chloride, polyvinyl acetate, polyvinyl butyral, and resins formed from their copolymerization, provide a series of materials that are tough, chemically inert, moisture and oil resistant. Their applications include linings and coatings for cans, food packaging and laboratory equipment, storage tanks, concrete vats and piping, and certain types of pickling and plating tanks. Some of the vinyl combinations have poor adhesion to certain types of metal; this can be improved, however, by the addition of modifying resins such as the alkyds.

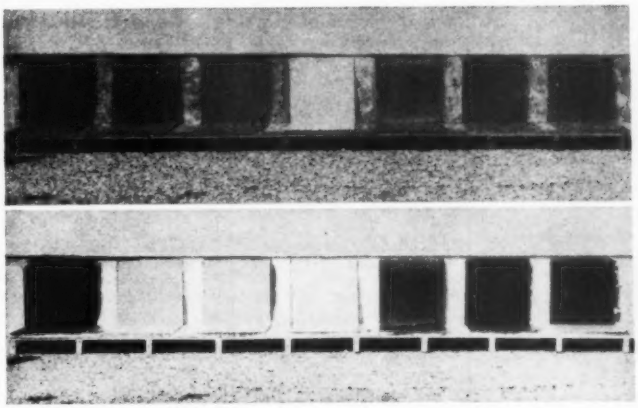
Production Requirements

In finishing industrial products, there are usually production requirements that must be imposed on the service characteristics of a coating. In production line finishing, drying time must be controlled between narrow limits to insure proper cure of the coating before handling, packaging and storage. Similarly, some production schedules require widely different methods of application, such as dipping, automatic spraying, roller coating and brushing. Significant adjustments in formulation are necessary for each method of application. When extremely short drying periods are required, forced drying or baking is used; or a coating that dries by solvent evaporation is selected—finer adjustments in drying time can be made through choice of solvents of varying evaporation rate.

Drying time of formulations containing a single resin can be varied appreciably. For example, a typical medium-length drying oil with modified alkyd, such as an average air-dry automotive enamel, is applied by automatic spray and dries rather rapidly under favorable temperature and humidity conditions. However, heating the newly finished parts with infra-red lamps can cut drying time to a fraction of the air-drying time. Another way to shorten drying time is to reduce the ratio of oil to resin—but only to a point that other properties, such as adhesion and brittleness, are not compromised for the particular application. Since film drying is accomplished by polymerization of the oil, the smaller the relative amount of oil present the more quickly a dry film is obtained.

Such alterations affect the properties of the dry film, and can be tolerated only within the limits permitted by these properties. A medium-oil alkyd finish exhibits good durability, gloss retention, flexibility and adhesion. Heat resistance, oil and grease resist-

ANTIFOULING PAINT prevented growth of barnacles on one side of this wing pontoon, which was exposed for 3½ months in Biscayne Bay, Florida. The clean side had been painted with a thin film of paint, composed of a blend of chlorinated rubber and an acrylic resin, in which a toxic pigment was incorporated. The fouled side had been coated with an orthodox alkyd enamel.



INFRA-RED reflecting pigments are useful for reducing heat absorption in such products as storage tanks, and for identification in darkness or camouflage. In the series of steel panels at the top, center panel is painted white for control: this photograph was taken with ordinary film. Below, picture was taken on infra-red film and the two panels to the left of the control show up lighter, since they have been coated with a special paint containing a chromium oxide pigment.

ance, and working properties are excellent. By decreasing oil length, hardness is improved, drying period is shortened, flexibility and adhesion are diminished and oil and grease resistance is increased. By increasing the ratio of drying oil, the film is rendered softer, more adherent and flexible, less resistant to oil and grease, and drying time is lengthened.

Certain changes in composition of an enamel for application purposes can be made without appreciable alteration in the properties of the dried film. Such adjustments usually consist in substituting one solvent for another of different evaporation rate or solvent power—resulting in a possible change in total solids. Lower boiling solvents are employed for spray application than for brushing, since a relatively smooth sprayed film will flow out to a uniform surface a little more rapidly. The solids content is reduced in formulations for spray application, since a great deal more solvent is lost during the spray operation than in brushing.

For dipping, solids and solvents must be adjusted to permit free flow of the coating, to provide a uniform film, and to prevent the formation of "fatty edges" where excess enamel drains off. For application by silk screen or roller coating, formulations have higher solids content and require higher boiling solvents, to permit easy working of the enamel and to prevent smearing or flowing.

Many synthetic resins are quite compatible and can be blended to obtain a large number of compositions, with nearly as many property variables. Such blends can be used to adjust application conditions. For example, a cellulose derivative can be blended with an alkyd enamel to shorten drying time. The improved drying will be accompanied by increased hardness in the dried film. However, such a combination might exhibit reduced resistance to moisture penetration and could not be considered acceptable where moisture resistance is of paramount importance. In making adjustments to conform to application requirements, the final effect on film quality must be kept in mind.

Table I—Characteristics and Suggested Applications of Various Vehicles

Resin Type	Characteristic Properties	Suggested Applications
Phenol-Formaldehyde (pure and modified)	Durability Heat resistance Chemical resistance Moisture resistance Fast drying Versatility	Electrical insulation Furniture finishes Food containers Marine finishes Beverage containers Tank car linings Food driers Chemical processing equipment
Alkyd (glycerol phthalate and modified types)	Durability Gloss retention Heat resistance Good adhesion and flexibility Oil and grease resistance Versatility	Refrigerator enamels Baking enamels Automotive and truck finishes Roller coating enamels Emulsified water paints Traffic signals
Coumarone-Indene	Heat resistant Chemical resistance Moisture resistance	Used in combination with other resins as low cost extenders, and to impart inertness to film
Urea and Melamine Formaldehyde	Hardness Clarity Oil and grease resistance Thermal stability	Refrigerator enamels Hospital equipment Kitchen appliances
Silicones	Heat resistance Hardness Clarity on baking	Insulating varnishes Heat-resistant enamels
Maleic	Relatively low cost Color retention Fast drying Light color Medium durability	Furniture sealers and lacquers Decorating enamels Interior varnishes and lacquers
Vinyls	Flexibility Inertness Toughness Oil resistance Clarity	Linings for storage tanks Chemical containers Laboratory equipment
Rubbers Synthetic, Natural, Condensation products	Flexibility inertness toughness Water resistance Chemical resistance Abrasion resistance	Concrete enamels aircraft Propellers chemical containers Air conditioning equipment
Chlorinated Rubber	Chemical resistance Compatibility with drying oils	Chemical resistant paints Masonry paints Marine paints
Nitrocellulose	High softening point Hard fast drying Relatively low cost	Decorative coatings Furniture (In combination with alkyds is used in variety of finishes)
Asphaltums	Water resistance Low cost Chemical resistance	Pipe coatings Roofing Chemical containers

Film Properties

In industrial products, finish ingredients are combined to strengthen the most critical properties, with some compromise of the less important factors. A coating for an airplane propeller must possess excellent resistance to abrasion and should be highly resilient, to withstand severe attack by sand particles, rain drops, ice and snow. Such a coating can be obtained by using elastic polymers such as the polysulfide rubbers, but at a sacrifice of hardness.

Nitrocellulose or alkyd resin finishes find little application for protecting surfaces or objects likely to come in frequent contact with alcohol or excessive moisture. A relatively short oil—highly polymerized phenolic varnish with some compromise of flexibility would be preferable. Finishes based on vinyl chloride-acetate provide excellent moisture protection and demonstrate good flexibility, although adhesion is somewhat inferior to the phenolic varnish. Similarly, vinyl coatings and to a lesser degree, heat convertible phenolics, can be employed where chemical resistance is the prime factor. Vinyl coatings can be applied to metals prior to fabrication; during the subsequent operations the film undergoes no appreciable deterioration. Table I gives a more complete listing of physical properties, with suggested applications.

In providing the most durable coatings for expensive products such as aircraft, automobiles, trucks and air conditioning equipment, actual cost of

the finishing material is an extremely small percentage of the total cost. Usually, specifying the more durable finishes prolongs the service life of the completed product to an extent that outweighs many times the extra cost of the material.

Finishes finding largest volume application are among the lower cost materials and include mainly alkyd resins, nitrocellulose derivatives, maleic resins, and the "oleoresinous" materials, which consist of a combination of drying oils with either natural or synthetic resins. Where conditions permit some sacrifice in quality, the cost of these finishes can be reduced further by the inclusion of cheaper materials such as coumarone resins, tall oil and rosin. For increased durability required in special applications, the more expensive vinyls, ureas, butyrals and pure phenolics are available.

Consideration also should be given to the cost of application. In automobile finishing, for example, the cost of nitrocellulose lacquer is cheaper than a high grade alkyd enamel, but the cost of additional labor required for rubbing down the lacquer to obtain a smooth finish, free of "orange peel", may exceed several times the difference in cost of material.

Table II—Typical Industrial Finishing Formulations

(Percent of each ingredient by weight)

I—Structural Steel Primers

Iron Oxide	24 4
Zinc Yellow	12 2
Magnesium Silicate	12 2
Litharge	0 5
Phenolic Varnish*	34 5
Mineral Spirit	11 0
Dipentine	2 2
Aromatic Solvent	2 2
5% Cobalt Drier	0 17
6% Manganese Drier	0 17
Anti-Skinning Agent	0 46

*Phenolic varnish is 25 gallon dehydrated castor oil vehicle, 60% solids.

II—Magnesium—Aluminum Primer

Zinc Yellow	38 0
Magnesium Silicate	6 7
Phenolic Varnish*	33 36
Mineral Spirits	21 44
24% Lead Drier	0 21
6% Cobalt Drier	0 08
6% Manganese Drier	0 04
Anti-Skinning Agent	0 17

*Phenolic Varnish is 15 gallon dehydrated Castor and Tung Oil Vehicle, 60% Solids

III—Baking Refrigerator Enamel

Titanium Dioxide	27 8
Short Oil Alkyd*	23 2
Long Oil Alkyd*	12 9
Urea Resin**	18 5
Xylol	17 6

*60% solids
**50% solids

IV—Furniture Sealer

Nitrocellulose 1/2 sec.	35 8
Maleic Resin*	53 7
Zinc Stearate	6 9
Dibutyl Phthalate	3 6

*60% solids

V—Furniture Lacquer

Nitrocellulose 1/2 sec.	35 8
Short Oil Alkyd (100%)	44 6
Maleic Resin (100%)	8 9
Dibutyl Phthalate	5 3
Blown Castor Oil	5 4

VI—Automotive Finish*

Nitrocellulose 1/2 sec.	25 0
Short Oil Alkyd (100%)	62 5
Melamine Resin	7 5
Dibutyl Phthalate	5 0

*Vehicle only

Applications

Formulas (I-VI) presented in Table II illustrate several common types of finishes. These formulations also demonstrate the versatility of the resin types, making them readily adaptable to varying conditions. It should be emphasized that these are only a few of the large number of formulations available.

Formula I lists the composition of a steel primer that protects steel against corrosion in damp industrial atmospheres. In practice, this primer is followed by one or two coats of appropriate enamel. This primer can be varied in numerous respects. For example, the phenolic varnish can be prepared from other drying oils or combinations, or the phenolic resin itself can be replaced by an oil-modified alkyd. Also, the pigmentation can be varied by substituting other inhibitive pigments, such as red lead, zinc dust or some combinations. For each variation, however, some alteration, even though slight, will occur in the properties of the film.

Formula II dries much more rapidly than I, as a result of the shorter oil length of the varnish and the considerably higher ratio of pigment to vehicle solids. This formula is applied for the protection of aluminum and magnesium and their alloys. Its speed of drying is adaptable to production line finishing. Zinc yellow primers have demonstrated a marked superiority over other generally accepted primer pigments for protection of the lighter metals. Substitution of short oil alkyd resin for some of the phenolic improves adhesion and drying time, but reduces moisture resistance. Where cost is a factor, some ester gum or even rosin can be substituted, but with a corresponding sacrifice in durability. A more limited choice of pigmentation is available in these applications, because chromate pigments have an almost unchallenged advantage for the protection of light metals and their alloys.

Formula III represents a typical refrigerator enamel; the ingredients have been selected to obtain an optimum balance between quality and cost. The urea resin imparts hardness and resistance to the action of fruit juices and other corrosive substances. The short oil alkyd also bakes hard and is not quite as expensive as the urea resin. The long oil alkyd imparts improved adhesion and flexibility to the film.

Formulas IV and V exemplify typical furniture finishes. An alternative to formula IV could consist of a simple solution of shellac and alcohol, although the designated formulation provides a more durable finish. The maleic resin and nitrocellulose when pigmented with zinc stearate form a hard adhesive film that is easily sanded to a smooth surface, with which the more durable formula V is quite compatible. The alkyd and maleic resins lend sufficient flexibility to the film to prevent checking, while remaining sufficiently hard to withstand normal abuse in service.

Formula VI demonstrates the variety of resins used in formulations of automotive finishes. The majority of automotive finishes contain nitrocellulose derivatives and ester type resins. They provide hard, fast-drying finishes (often baked as Formula VI) that can be rubbed and polished to glossy, mirror-like surfaces. Careful formulation, including a critical balance of solvents, is necessary to avoid undesirable effects such as "orange peel", which requires extensive rubbing to remove.

By varying the ratio of constituent ingredients, the properties of the film can be controlled accordingly.

The finish on most products should be as carefully planned as any of the components of the product; a properly designed finish contributes immeasurably to the service life, utility and appeal of the product.

Lubricating and Hydraulic Oil Filters for Aircraft

Foreign abstract from "Filtration as Applied to the Aircraft Industry" by J. Parkinson, *Aircraft Engineering* (London), p 337, November 1948.

THERE ARE two schools of thought on oil filtration: (1) By-pass filtration, whereby a small percentage of the oil is filtered often to a high degree of efficiency; and (2) The full-flow method, whereby all the oil is filtered all the time, removing all harmful particles.

The first method is fairly popular in the automobile engineering industry, but it has not found any favor on aero-engines, therefore, it will not be further considered. The full-flow method of filtration, however, will be treated in some detail.

In the full-flow method the filter is preferably mounted on the pressure side of the oil pump. While the filter can be supplied as a separate unit, it may be more convenient because of weight and space limitations to make the casing of the filter a part of the engine cowling.

Efficiency in oil filtration depends on many factors including the use of an appropriate filtering medium capable of arresting the finest particles likely to cause damage; and a sufficiently large filtering area so that the velocity of the oil through the filter medium is low, the impurities being trapped and not driven through the filter medium. A suitably designed relief valve must be provided to by-pass the oil when starting cold, and to prevent failure of oil flow to the engine should the filtering element become overloaded with dirt. Further, the by-pass must be so arranged that there is no possibility of washing the collected dirt off the element and re-circulating the dirt when the by-pass is operating.

Filter elements are usually either metallic or felt. The metallic type was widely used in Germany both before and during the war. It often consisted of a pile of thin metal rings, slightly separated, the oil flowing from outside to inside between the rings. Scraper blades were provided between the rings so that the filter pack could be cleaned without dismantling. Cleaning was performed by a ratchet connected to the throttle lever, or the cleaning device was operated by a small oil turbine. While this type of filter is not much more than a fine strainer, it will normally remove particles down to 0.005 in. thick.

A variation of this type uses a flat wire ribbon on which small projections are formed. The ribbon is wound round in the form of a spiral, giving filtration down to 0.0005 in. The fineness of filtration is limited by the spacing, which in turn depends on the height of the projections formed on the wire strip. While limiting the width of the particle, this filter does not prevent a long thin piece of dirt entering the mechanism.

With a felt filter element, a much finer degree of filtration is assured than with a metallic element.

Recent tests by oil companies have shown that no filter can be deemed efficient if it removes less than 97 percent of the total impurities. Further it has been proved that the last 3 percent of impurities, in which sizes vary from 0.006 to 0.0001 in. dia, is the most harmful. Particles of this size are able to enter bearings, span the oil film and wear away the bearing surfaces. The felt type of filter element can best remove all or as many particles of this size as is possible within design requirements and space limitation.

An oil may be discolored and yet be perfectly suitable for use when the contamination consists of the very small particles that are not large enough to do damage. To obtain amber-clear oil would require an exceptionally large filter, having a very fine degree of filtration.

It has been stated by L. Rosenfeld that 'it may be misleading to judge the usefulness of an oil by its color; an oil may contain colloidal carbon particles and look absolutely black, although the contamination may be quite harmless, and another oil may look transparent and still contain harmful abrasive matter which is also transparent.'

Maximum filtration area is best achieved by corrugating the filter medium into a convenient formation, usually panel or cylindrical. A cylindrical formation having an area of 600 times greater than the oil inlet is most suitable. The graph in Fig. 1 shows the resistance curves of three filters designed to meet the same efficiency requirements, all being the same size and interchangeable, when tested with oil to specification DTD 109. As seen from Fig. 1, the Vokes filters

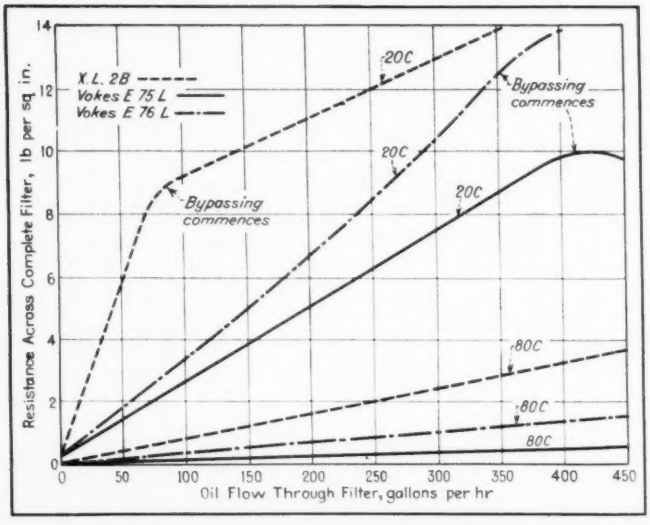


Fig. 1—Resistance curves of three different filters of the same size.

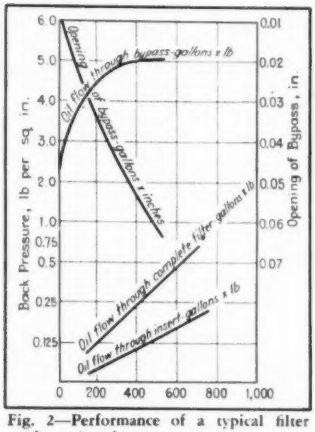


Fig. 2—Performance of a typical filter used on aircraft gun turrets.

designed on the foregoing principles were able to meet these requirements for an extremely low pressure drop.

The third principle of design is that provision must be made for the oil to by-pass the element when it is cold or when the filter has not been adequately serviced. By-passing must be infallible, and must take place when only a few pounds pressure above normal has been generated.

In one type, the filter element itself acts as a by-pass device. A short tube with ports is attached to the top of the filter element, an oiltight joint being made with the head casting by means of a synthetic rubber seal, the pressure being provided by a spring at the base of the element. The differential pressure required to operate the release valve is two pounds.

By the use of a synthetic sealing ring, any small pieces of dirt trapped at the valve seat become imbedded in the ring; thus always assuring an adequate seal. The curves in Fig. 2 show the performance of a typical filter used on aircraft gun turrets during the war. The filter has a rated capacity of 500 gallons per hr when tested with light oil having a viscosity of 39 seconds Redwood at 70 F. From Fig. 2 it is seen that the filter element has a back pressure of less than $\frac{1}{8}$ lb per sq in., while the back pressure through the whole filter is approximately $\frac{1}{3}$ lb per sq in. This performance compares favorably with other oil filters having 5 to 6 lb per sq in. back pressure.

The curves in Fig. 2 show the small opening of the by-pass aperture required to pass a considerable quantity of oil. The by-pass did not start to open until 2 lb per sq in. back pressure had been generated. When the by-pass was open only 0.05 in. the amount of oil passing was 380 gallons per hr. Pieces of foreign matter lodged in the release valve may be a significant cause of danger.

The graph in Fig. 3 summarizes tests with oil specification HD 30, on an oil filter having a relief valve of the metal to metal contact type when small quantities of swarf were purposely introduced into the system. The oil temperature was maintained at 22 C. As the oil flow was gradually increased, and held constant at various rates, the pressure drop across the filter at each stage was recorded. When an oil flow of 200 gallons per hr was reached, this rate was maintained. A few grams of swarf were then introduced to the pressure line approaching the filter. The oil flow was then lowered while the temperature was maintained. The flow was then increased and held constant at various rates of flow, while pressure drop recordings were made.

The initial curve rises steeply until an oil flow of approximately 130 gallons per hr is reached, the pressure drop at this point being 7.7 lb per sq in. About this point the curve flattens, proving that the by-pass valve is in operation. The final curve resulting after the introduction of the swarf is practically a straight line with a lower gradient than the initial curve, with no deviation from a normal course to indicate that the by-pass valve comes into operation.

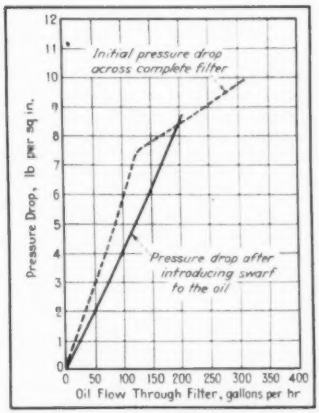


Fig. 3—Flow test on oil filter having a relief valve of the metal to metal type.

From these results, it is obvious that the introduction of swarf had jammed the by-pass valve and that there was a constant leakage of unfiltered oil throughout the complete range of oil flows.

Linestarting Direct Current Motors

From "Linestarting Direct Current Motors" by E. C. Watson, Westinghouse Electric Corporation, presented at the winter meeting of the American Institute of Electrical Engineers in New York City, February 4, 1949.

THERE IS an ever-increasing demand for pushing upward the horsepower, speed, and voltage limits of d-c motors capable of being linestarted. This is because linestarting permits the use of a simple switch and overload protection, thus eliminating resistors and additional contractors. This simplification of control results in both space and cost savings.

Among those factors which limit the application of a line starter to a d-c motor is the type of circuit which is used to supply power for the motor. A d-c motor has relatively low resistance and inductance and starting current is very high. This means that the disturbance to the line is much greater in starting a d-c motor than for a corresponding size a-c motor.

The machine to be driven will sometimes limit the application of linestarted d-c motors. The high starting current drawn by the motor develops a very high torque. Gears, belts and other components in the driven machine must be designed to withstand this sharp, high-peak torque. Since the starting and accelerating torque is large, some overshoot in speed is likely to occur. The driven machine must be such that momentary overshooting of speed is not objectionable. In some cases this overshoot of speed amounts to five percent.

From the standpoint of motor performance, one of the most important limitations is sparking or flashover at the commutator. Since the currents are high at line starting, there is always some spit at the brushes. As the size of the motor increases, this action increases and very often the sparking is so bad that flashover results. Flashover must be avoided as it results in severe burning and often burns open the circuit. Sparking, even though severe, usually will cause no permanent injury unless the motor starts a high inertia load. In normal service, the developed torque is so great that

the motor quickly comes up to speed. Duration of the severe sparking is not sufficiently long to cause permanent damage to the commutator or brushes. The frequency of the starts and duration of the normal run period greatly affects this. In a normal motor started not over six times an hour, the commutator will be cleaned up by the polishing action of the brushes.

Another point of poor performance in the motor concerns heating. There is some danger of local hot spots developing unless the number of starts is limited, so that the local heating has a chance to distribute itself.

In designing the armature of a motor for line start service, it is necessary to carefully design the motor for good commutation. This means select the number of bars on the high limit, reduce the commutating voltage and the induced volts per bar to a minimum. The normal limit for possible flash-over should be used. The armature of a linestarted motor should be well braced to prevent movement of the conductors under the high stress developed during the initial period.

In designing the fields for a line-start motor, care is indicated. Better results will be obtained if a full complement of commutating poles is used instead of the normal practice of using only one-half the number of commutating poles. Series motors can be linestarted in large sizes without ill effect. Shunt-wound motors are difficult to linestart satisfactorily. When a motor is started across the line, the shunt field is energized at the same time as the armature but the field requires appreciable time to establish the flux. Hence, the armature is well accelerated under a weak field condition which may produce overshooting of speed and usually dangerous sparking at the commutator. The degree of over-shoot will vary somewhat with the inertia of the load to be accelerated. When a compound winding is used, the series field aids in establishing the flux and so the motor is not accelerated with as weak a field. By adjusting the amount of compounding, this is easily controlled. A motor with practically no external inertia will over-shoot unless very heavily compounded, while a high inertia load will require a small amount of compounding to hold it within acceptable limits. As one approaches the upper limits of line starting, promiscuous application of motors is not recommended. Each motor should be checked against the load to be sure the proper amount of compounding is incorporated.

Table I—Plant and Laboratory Corrosion Tests in Fruit Juices and Syrups

Material	Condition	Corrosion Rate Inch Penetration Per Year			
		Inconel	Nickel	Monel	18-8 Stainless
Tomato Juice	Aerated, Room Temperature	0.0000	0.012	0.003	——
Tomato Juice	Unaerated, Room Temperature	0.0000	0.008	0.0001	——
Tomato Juice	*Fully Aerated, 170 F.	0.0002	0.044	0.015	0.0003
Tomato Juice	*Fully Aerated, 195 F.	0.0002	0.016	0.008	0.0002
Lemon Juice	Aerated, Room Temperature	0.0003	0.020	0.010	——
Lemon Juice	Boiling Under Reflux	——	0.014	0.0006	——
Lemon Juice	Unaerated, Room Temperature	0.0003	0.0005	0.0005	——
Lemon Syrup	Fully Aerated, Room Temperature	0.0000	0.001	——	0.0000
Lemon Syrup, Diluted	Fully Aerated, Room Temperature	0.0002	0.034	——	0.0004
Lime Syrup, Acidified into Citric Acid	Unaerated, Room Temperature	0.0002	0.0001	0.0001	0.0001
Pineapple Juice	Aerated, Room Temperature	0.0000	0.018	0.005	——
Pineapple Juice	Unaerated, Room Temperature	0.0000	0.004	0.0007	——
Pineapple Juice	*Alternate Immersion, 132–178 F.	0.0004	0.010	0.006	0.0001
Pineapple Juice	*Fully Aerated, 180 F.	0.0007	0.036	0.030	0.0002
Pineapple Juice	*165–175 F., 16–18 in. Vacuum	<0.0001	0.0045	0.003	0.0003
Grape Juice	Aerated, Room Temperature	0.0000	0.025	0.005	——
Grape Juice	Unaerated, Room Temperature	0.0000	0.006	0.002	——
Grape Juice	*Boiling Under Reflux	0.0004	0.007	0.0003	0.0001
Orange Juice	Boiling Under Reflux	——	0.008	0.0007	——
Orange Syrup	Fully Aerated, Room Temperature	0.0000	0.0007	——	0.0000
Orange Syrup, Diluted	Fully Aerated, Room Temperature	0.0002	0.025	——	0.0004
Apple Juice	Aerated, Room Temperature	<0.0001	0.0004	0.0005	——
Apple Juice	Unaerated, Room Temperature	0.0000	0.0001	0.0001	——
Apple Cider	*Unaerated, Room Temperature	<0.0001	0.001	0.0009	0.0001
Apple Cider	Unaerated, Boiling	<0.0001	0.002	0.0012	<0.0001
Grapefruit Juice	2.7 percent Citric Acid, Hot	0.0002	0.0002	0.0001	0.0002
Grapefruit Juice	2.7 percent Citric Acid, Cold	0.0007	0.0006	0.0005	0.0007
85 percent Grapefruit Juice & 15 percent Orange Juice	*Aerated, Room Temperature	<0.0001	0.022	0.002	<0.0001
Caramel Color Syrups	*Unaerated, 212 F.	0.0014	0.0015	0.0011	<0.0001†

* Indicates field tests.

† Specimens pitted to a max. depth of 0.001 in. on surface and 0.011 in. in crevice formed by bakelite and metal surface.

Effect of Foods on Alloy Steels

From "The Resistance of Alloys to Corrosion During the Processing of Some Foods" by J. F. Mason, Jr., *Metallurgia*, October 1948.

COMPARATIVELY few quantitative tests have been published on the relative corrosion resistance of metals, especially alloys, and their suitability for particular foodstuffs. In field investigations made by the author, use was made of the spool-type specimen holder which permitted the simultaneous testing of a large number of metals and alloys in operating equipment under actual conditions of service, thus giving direct comparisons of the relative performance of the various materials studied.

The method of test was substantially in accordance with ASTM Recommended Practice for Conducting Plant Corrosion Tests, A224-41. Two similar specimens of each material were included on each spool. Each of the test specimens used had an exposed area of 0.5 sq dm.

Fruit Juices and Syrups. Table I gives the results of a number of plant and laboratory corrosion tests on Monel, nickel, Inconel and 18-8 stainless steel in a variety of fruit juices and syrups under different conditions of exposure. Generally, it will be noted that the materials tested performed satisfactorily, and this is borne out in practice since they are used rather widely for equipment in the processing, storage and dispensing of fruit products. However, in some applications where the corrosive conditions are especially severe due to a combination of high temperature and strong aeration, Inconel and 18-8 stainless steel prove to be the better materials. When complete freedom from tarnishing of equipment is desirable, Inconel and 18-8 stainless steel are preferred.

Sprayed Metal Physical Properties

From "Some Characteristics of Sprayed Metal Coatings" by G. Tolley, *Metallurgia*, September 1948.

ADHESION OF SPRAYED METAL is an important factor depending on whether the coating is applied for corrosion protection or for its structural importance as in building-up. Adhesion tests, are, however, difficult to devise. Nevertheless, such tests are of value in showing that metal-sprayed coatings can be applied having excellent adhesion to the base metal. One method consists of applying a sprayed coating to a steel tensile specimen and then fracturing the test piece. After fracture the specimen is examined and the distance from the fracture to the first cracks was found and also the distance from the fracture at which it ceased to be possible to remove the coating by scratching. Results for several metals are shown in Table I.

Shear tests are often called for, and some results obtained on 1 in. shafts are given in Table II. These figures show that adhesion between the metal-sprayed coating and the base metal can be high when the surface has been prepared in the correct way.

Bend tests have little significance in relation to the adhesion of sprayed coatings and yet they are often required. They may be of use where a job has to undergo considerable distortion after spraying, although normally, spraying should be the last process of fabrication in order to avoid the necessity of bending. Generally, a steel sheet sprayed with under 0.004 in. thickness of metal can be bent through 180 deg without the coating cracking off. Above this thickness the coating will start cracking when bent through angles less than 180 deg. The angle of bending before cracking commences depends more upon the thickness of the sprayed coating than upon the intrinsic adherence of the deposit.

Because of the porosity and oxide content of sprayed metal the hardness is different from that of the cast or wrought metal. On the one hand porosity will cause a lower indentation hardness, while on the other the oxide content will cause a higher scratch hardness than the original metal in massive form. Factors that affect these two characteristics of sprayed metal will, therefore, cause a variation in the hardness of the deposit.

Results for scratch hardness, indentation tests and seleroscope hardness are given in Table III.

It is seen from these results that the scratch and seleroscope figures for sprayed metal are higher than for the cast metal, whereas the ball indentation figures show that the sprayed metal is probably slightly softer than the cast metal—a difference in surface and depth properties.

Table I —Fracture Tests

Metal and Process	Breaking Load, kg	Distance to Cracks, mm	Stress at Cracks, kg/sq mm	Scratching Limit, mm	Stress at Scratching Limit, kg/sq mm	Remarks
ZW1	870	115	29	125	31	Partial adherence in cracked zone
ZW2	875	113	29	128	31	
ZW3	875	113	29	122	31	
ZP2	950	114	32	111	30	
AW2	950	97	32	100	32.5	
AP2	875	...	..	...	Coarse and whole deposit easily scraped off	
BW2	1,075	82	29	85	30	As ZW1
CW2	975	99	26	105	28.5	"
SW2	1,050	102	29	104	30	"

Z Zinc — A Aluminum — P Powder Process
B Brass — S 18:8 Stainless Steel — W Wire Process
C Copper — 1, 2, 3 No. of layers 0.04 mm

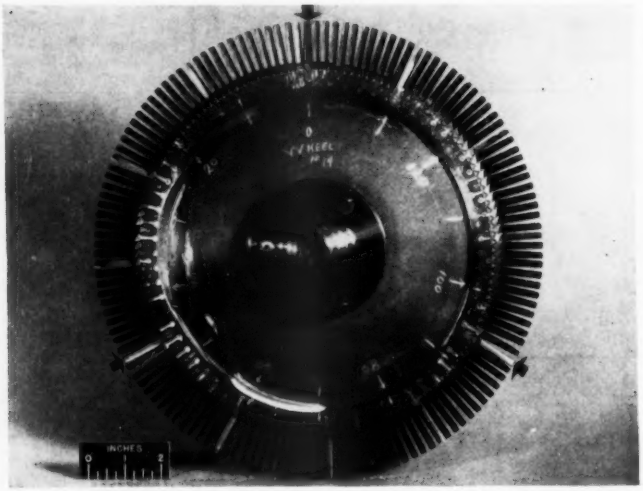
Table II—Shear Tests

Shafts threaded 30 to the inch; collars ¼ in. thickness, without notches.

Phosphor Bronze	2.9	tons/sq in.
Nickel	4.85	"
Mild Steel	3.9	"
18/8 Austenitic Steel	6.7	"
0-85% Carbon Steel	7.1	"
Zinc	0.56	"

Table III—Hardness Tests

Metal or Alloy	Cast Material	Sprayed Coating	Sprayed Block Tested on Top	Sprayed Block Tested on Side
Scratch hardness:		(Width of scratch in mm).		
Tin	0.08	0.056	0.055	0.055
Aluminum	0.06	0.044	0.048	0.05
Zinc	0.05	0.032	0.033	0.035
Copper	0.05	0.029	0.03	0.03
Iron	0.02	.....	0.02	0.022
Brass	0.05	0.032	.....	.....
Bronze	0.023	0.025	.....	.....
Ball hardness:		(Diameter of indentation in mm).		
Tin	>0.8	0.77	0.8	0.8
Aluminum	0.61	0.44	0.57	0.62
Zinc	0.44	0.42	0.55	0.57
Copper	0.54	0.38	0.42	0.54
Iron	0.32	.....	0.33	0.38
Brass	0.54	0.43	.....	.....
Bronze	0.3	0.43	.....	.....
Seleroscope hardness:				
Tin	5-6	.....	11.5	11.0
Aluminum	6	.....	12.0	10.0
Zinc	12	.....	19.0	13.0
Copper	17	.....	50.0	47.0
Iron	25	.....	55.0	45.0



CERAMAL TURBINE BLADES (next to arrows), made of titanium carbide—cobalt alloy, may be solution to current impasse in heat-resistant materials. Special blades outlasted 108 all-metal counterparts during high temperature tests.

Ceramic-Metal Alloy Has Thermal Shock Resistance Needed for Turbine Blades

THE MOUNTING URGENCY for more heat-resistant materials for turbine blades has grown into a battle between special metal alloys and ceramics. Now it looks like the battle shortly may be won by neither one of these contenders—but by a material combining both.

One of the most promising alloys of this ceramal series is a carbide-type consisting of 80 percent titanium carbide and 20 percent cobalt. This material has a relatively high thermal conductivity of 20.56 Btu/in./hr/sq ft/deg F, a thermal expansion of 5.0×10^{-6} in./in./deg F, a modulus of elasticity of 55,000,000 psi and high tensile strength. The thermal shock resistance of the alloy is therefore considered adequate for turbine blade use.

The high thermal conductivity of this ceramal enables it to transfer heat to the turbine wheel so rapidly that a turbine blade of this material actually has run cooler than a heat-resistant metal-alloy blade on the same disk. High thermal conductivities also are desirable for blades that are to be cooled because heat in the blade trailing edge, where it is hard to provide cooling passages, can be conducted to the center of the blade.

Another important property of ceramals is their low specific gravity. It allows turbine blade weight to be reduced from about one-half to two-thirds that of a comparable metal alloy blade, with reduction in centrifugal stress on the blade root.

It appeared that this new material possessed all of the desirable characteristics for a superior turbine blade. That left the question of its thermal shock characteristics. An investigation was conducted at the NACA Lewis Laboratory to determine: (1) resistance to thermal shock, (2) short-time tensile strength at elevated temperatures, and (3) performance characteristics under simulated service-test conditions.

The apparatus for the thermal shock evaluation consisted of an electric furnace containing non-metallic resistor bars to heat the specimen, and an air-quenching system for cooling. Specimens were inspected for internal and external flaws by radiographic and fluorescent-oil methods, respectively.

A specimen was placed in the preheated furnace for 10 min, after which it was removed to the quenching air stream within $\frac{1}{2}$ to $1\frac{1}{2}$ sec and kept there for 5 min. The specimens were so placed in the air stream that the flat surfaces were parallel to the flow of air.

The quenching air, supplied at 80 F, flowed at the rate of 50 lb per min through a 6 in. dia pipe at a velocity of approximately 50 fps. The tests indicated that this equipment heated the specimen at the rate of 140 F per sec to 1,800 F, and cooled it at the rate of 200 F per sec. This heating and cooling operation constituted one cycle.

A specimen was subjected to 25 of these cycles with the furnace temperature at 1,800 F. If it survived this treatment, 25 cycles were successively repeated with furnace temperatures of 2,000, 2,200 and 2,400 F, or until failure occurred. The appearance of a crack was considered a failure.

The simulated service test was performed on a small gas turbine with hot gases supplied from a turbojet combustion chamber. These ceramal blades were installed at equal intervals about the disk (see illustration above), the remaining 139 dovetails being fitted with metal blades obtained from the U. S. Air Force.

The turbine was motor-driven up to about 6,000 rpm and held there for five minutes as a preliminary safety check. Combustion was started and test conditions attained in approximately three minutes. The wheel was then operated at required conditions until failure, which was indicated by a change in pitch of the sound.

These severe tests indicate the future promise of ceramals. The short-time tensile-strength evaluation at 1,800 F showed a tensile strength of 33,200 psi based on the original test-section area. The heat-resistant alloys commonly used have an average value of about 33,000 pounds per square inch.

At 2,200 F, the specimen showed a short-time tensile-strength of 13,200 psi. There is little data on other alloys tested at this extremely high temperature with which to compare this figure. But it can be considered good since this temperature approaches the melting points of various metal alloys considered for this application.

The ceramal survived 25 cycles of the thermal shock evaluation at 2,400 F, whereas a zircon ceramic, regarded as having good thermal shock properties, survived one cycle at 1,800 Fahrenheit.

A titanium carbide specimen was in-

vestigated in order to provide a comparison with the titanium carbide-cobalt ceramal. This test ceramic proved highly resistant to thermal shock, surviving 14 cycles at 2,400 F in one test and 21 cycles at the same temperature in another.

But it is the results of the simulated service test that are of greatest interest. At the end of 12 hr 13 min of running the turbine at speeds varying from 10,000 to 15,000 rpm at 2,200 F, a total of 108 metal blades had been replaced. Only at this point did the first ceramal blade fail.

During operation, a film consisting of two separate layers formed on the ceramal blades. The outer layer was mainly titanium dioxide (rutile—from which titanium is extracted). The inner layer consisted mainly of cobalt titanate. No significant change occurred in the base material, an important test result in the light of phase transformations with temperature change of some ceramics.

Within the limits of this series of tests, this scale formation was not considered important since the scale was tenacious and tended to preserve the aerodynamic shape of the blade and to inhibit any scaling tendencies. For more severe operation, protective coatings against oxidation might be required if the naturally-formed oxide coating is not sufficiently protective.

Many Companies Producing Ductile Cast Iron

AFTER YEARS of experimentation with various alloying elements and processing techniques, American and British engineers have carried the development of nodular cast iron to the point where it is now commercially available in growing quantities—a tonnage of 10,000 to 15,000 is estimated for this year.

Patent applications have been filed both here and abroad, and some thirty licensing agreements have been drawn up in the U. S. between The International Nickel Co., Inc. and foundry concerns in the east and midwest. Foreign licensees will be in production before many months have elapsed.

American researchers have settled on magnesium as the key alloying element for producing the spheroidal graphite structure. Costing only about 20 cents per pound, the metal can be introduced separately or in combination with copper or nickel, at a fraction of the cost of the cerium used by the British.

It is not mandatory that "carriers" like copper and nickel be used to overcome the volatility of the magnesium. If special properties attributable to the presence of copper or nickel are desired in the finished casting, these alloying elements can be used in combination with the magnesium.

The nodular irons produced with magnesium are ductile, are free from graphite in flake form, behave elastically like cast steel. With simple annealing, tensile strengths can reach 75,000 psi. Normalizing and tempering develop tensiles up to 127,000 psi. Further treatments, it is expected, can lift tensiles still higher.

The nodular irons do not deform under high temperatures as ordinary castings might. Treated, they are highly machinable. Although ordinary cast iron forms a broken chip when cut with a tool, annealed nodular iron cuts like steel, producing a continuous chip. The material is also easy to weld with the special rods developed for gray irons, and the nodular graphite does not become flake graphite again during the welding.

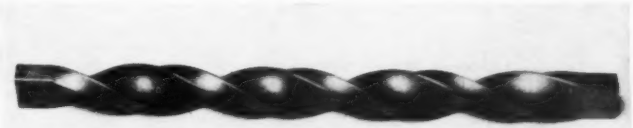
The advocates of nodular iron look for wide industrial applications. High strength and rigidity make it useful for machine tools, pumps, heavy equipment. Ductility provides thermal shock resistance for parts like railroad car wheels. Resistance to growth and oxidation may lead to uses in engines and furnaces that operate at high temperatures in the range from 1,000 to 1,500 Fahrenheit.

Utilizing the significant engineering properties gained with the new material, the wall thicknesses of cast iron pipe can be reduced by nearly 30 percent; the weight of large castings weighing more than 1½ tons can be lowered by significant amounts up to 25 percent.

The interest exhibited in this distinctly promising engineering material can be evaluated by noting the following partial list (as of May 25, 1949) of companies already working under license agreement: Albion Malleable Iron Co., Albion, Mich.; The Anstice Co., Inc., Rochester, N. Y.; Atlas Foundry Co., Irvington, N. J.; Benton Harbor Malleable Industries, Benton Harbor, Mich.; Bison Castings, Inc., Buffalo, N. Y.; Chambersburg Engineering Co., Chambersburg, Pa.; Cooper-Bessemer Corp., Grove City, Pa.; Dostal-Per Mold Foundry Co., Pontiac, Mich.; Francis & Nygren Foundry Co., Chicago, Ill.; Frank Foundries Corp., Moline, Ill.; Kutztown Foundry & Machine Co., Kutztown, Pa.; Lynchburg Foundry Co., Radford, Va.; Motor Castings Co., Milwaukee, Wis.; Noblesville Casting Co., Noblesville, Ind.; Otaco Limited, Orilla, Ontario; Pitz Foundry, Inc., Brooklyn, N. Y.; Prospect Foundry, Minneapolis, Minn.; Ritter Co., Inc., Rochester, N. Y.; James Spence Iron Foundry, Jersey City, N. J.; Sacks-Barlow Foundries, Inc., Newark, N. J.; Sterling Foundry Co., Wellington, Ohio; Straight Line Foundry & Machine Co., Syracuse, N. Y.; Texas Foundries, Inc., Lufkin, Texas; Treadwell Engineering Co., Easton, Pa.; Youngstown Foundry & Machine Co., Youngstown, Ohio; Sandy Hill Iron & Brass Works, Hudson Falls, N. Y.

Survey Indicates Graduating Engineers Avoid Drafting Jobs

TO PLAN EFFECTIVE CURRICULA for preparing mechanical engineering students for careers in design, the help of industry has been enlisted in developing specifications for such training. A survey of a hundred industrial organizations in twenty-three states was recently made to obtain the answers to such questions as: What personal characteristics and what special features of training are needed? How widespread is the demand for such graduates? Is a definite training program established for such men in industry? Are qualified graduates interested in design careers? In addition to these broad questions, certain per-



COLD-WORKED CAST IRON BAR having spheroidal graphite structure exhibits properties of cast steel when twisted. Bar section measures ¼ by ½ inch.

tinent details of our present curricula need to be viewed critically.

All important industrial centers throughout the country were sent questionnaires, consideration being given to as many as possible of the outlets in industry for the talents of mechanical engineers in the field of design. These outlets included large and small plants engaged in various types of manufacture, such as mass-production parts, special designs of heavy machinery, built-to-order high-precision products and assembly work.

A list of pertinent questions was prepared and distributed to manufacturers, public utilities, consulting engineers, chemical and metallurgical plants, and the like. The individuals addressed included chief engineers, chief designers, vice-presidents in charge of engineering, and many others in related positions. In large companies, separate replies were sought and received from plants in different locations. Data were also obtained from representatives of the personnel departments specializing in hiring technical personnel or in their training.

Seventy percent of the industries surveyed hire graduate mechanical engineers for a specific assignment to design work. An additional few indicate that they wish to obtain such men but in recent years have been unable to find them.

While only 49.5 percent follow a specific training procedure with young designers, several replies emphasized industry's needs for further planning in this direction.

In a number of instances it was stated specifically that industry's part in the training program should begin before graduation. A few indicated a definite preference for cooperative education, including summer jobs working for a senior designer.

While no part of the questionnaire was specifically directed toward an appraisal of the graduate's attitude toward design, unsolicited comments referred to the reluctance toward undertaking careers in design. This reluctance seems to be related closely to a dislike of drawing work. Even students of demonstrated aptitude and professed interest in the field are inclined to avoid opportunities for employment where definite mention is made of an assignment to the drafting room for a training period.

Drafting ability in the prospective employee is sought by 79 percent of the replies to the questionnaires. Furthermore, the men who are hired spend, on the average, 65 percent of their time on the drawing board for the first year. This percentage decreases to about 30 percent in the third year. The drawing-room work is viewed (and rightly so) as a vital part of the training, along with shopwork. Granting without question that this experience is necessary to the designer, means of improving the situation need to be considered. To this end, the following suggestions are offered:

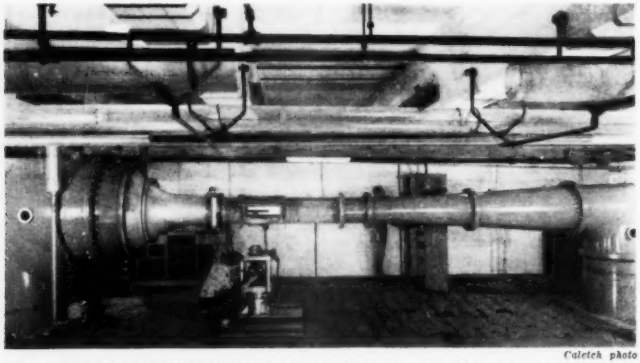
1. Emphasis in "engineering drawing" courses needs to be placed on providing the engineer with a means of expressing his ideas graphically, encouraging his originality and ingenuity. Here the responsibility is that of the college.
2. Students should be encouraged to illustrate their thoughts and explanations with sketches. Here again the responsibility belongs to the college.
3. Particular stress should be on the opportunity for individual creative work. In the case of a man who has promise, regardless of his lack of experience, he should be given an original project, however simple. Call him a "project engineer." Let him feel that his tasks are such that they require a college education, and not simply high-school training. Here the responsibility is industry's.
4. It is the responsibility of experienced engineers and the professional societies to acquaint students with the rewards and satisfactions of work in the field of machine design.

Hydrodynamics Laboratory Open for Industry's Use

FORMERLY RESTRICTED to military research, California Institute of Technology's Hydrodynamics Laboratory is now tackling basic problems that affect the design and operation of every type of hydraulic equipment, from ships' propellers to hydroelectric turbines.

The Pasadena laboratory's water tunnels—in which speeds up to 100 fps have been attained—can now be commissioned by manufacturers for special work. However, that work must center around development of a basic nature, with results pertinent in more than one field.

The laboratory includes four main sets of equipment, each a complete unit. In the high-velocity tunnel, a camera capable of 20,000 frames per second is used to record data. A free-surface water tunnel is used to study missiles traveling near the surface of the water where wave formation is a problem. A third tank permits study of the action of torpedoes launched from aircraft into and through bodies of water. In order to test the flight path of torpedoes models are mounted on a launching wheel and hurled at a predetermined speed while cameras record data. A ripple tank is used for examining wave formations that are of particular importance in the design of harbor installations. Through ripple tank studies, more information can be learned regarding supersonic flow in air. This type of study is possible because the mathematics of shock waves on the surface of water and those in air at supersonic speeds are similar.



Caletch photo

HIGH SPEED WATER TUNNEL in California Institute of Technology Hydrodynamics Laboratory attains a speed of 100 feet per second. Movie camera is used to record data on models such as torpedo shown in test section.

Washington Notes

Isolation of Pure Metallic Zirconium Nearly Complete

Spurred by its success with isolation of pure metallic titanium last year, the U. S. Bureau of Mines has intensified research on pure metallic zirconium.

Early research on the new metal has shown that its strength at moderate temperatures (below 900 F) is even better than the average stainless steel. Tensile strength for cold worked zirconium is 115,000 to 140,000 psi; the annealed strength varies from 42,000 to 70,000 pounds per square inch. Yield strength is 80,000 to 120,000 psi cold worked; 30,000 psi annealed.

Zirconium has a higher melting point than many low-carbon steels, steel being about 2,700 F, zirconium about 3,400 Fahrenheit. While zirconium begins to scale and oxidize at 900 to 1,100 F, steel does not exhibit these conditions until it has reached temperatures several hundred degrees higher.

At present the metal has been brought to 97 to 98½ percent purity, the impurity being the rare metal hafnium. Although there never has been enough hafnium isolated to provide sufficient tests of its properties, Bureau of Mines metallurgists know that it is very heavy, and has properties similar to platinum. Its ability to withstand corrosion, the metallurgists believe, will be even better than zirconium. Once a way is devised to separate the two, a completely new set of characteristics may be found for absolutely pure zirconium, as well as for hafnium.

Although sponge zirconium at present costs about $30 a pound, the price is expected to be halved shortly when a new system of refining the ore goes on the line at the Bureau's pilot plant in the West.

Ordnance Contracts to Hinge On Economy in Design

Design engineers now face a real challenge as the result of a recent change in procurement policy by the Army Ordnance Department. Ordnance's new policy: "Industry should play the mass production role in procurement of materiel, while manufacturing arsenals act as job shops and sources of technical knowledge."

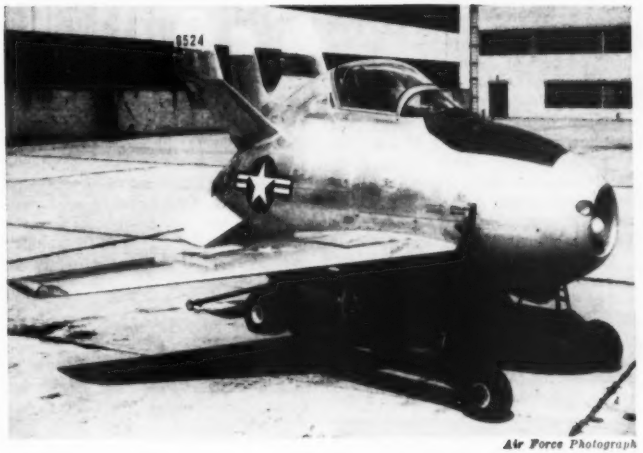
The arsenals are still responsible for procurement of materiel, but they are mandated to show why industry is unable to do the job before going ahead and doing it themselves.

Through this mandate, the engineer is faced with delivering to his boss a production line and product plan that will enable the manufacturer to bid competitively. In all but a few cases, competitive bids will be asked by the arsenals on new production jobs. Cost will be the prime factor in determining whether a manufacturer or an arsenal does the job.

Each of the eleven Ordnance procurement centers located throughout the country has a list of acceptable manufacturers for each type of commodity procured by that office. The manufacturer can get on those lists by contacting the arsenal procuring his type product and showing his ability to produce. The abilities of the design engineers in each concern will therefore play a leading role in determining who gets the contracts.

Bureau of Mines Making Liquid Fuel From Coal

A new synthetic liquid fuel got its first real test recently when a Burlington Route Diesel train, using oil made from coal, ran from St. Louis to Louisiana, Missouri. The occasion for the special trip was the dedication of the U. S. Bureau of Mines' new coal



Air Force Photograph

Air Force Rolls Out Parasite Jet Fighter

The McDonnell XF-85, Air Force parasite jet fighter, never touches the ground, as it has no wheels, and is "rolled out" on a specially-constructed dolly. Its home is the bomb-bay of a B-36 bomber from which it takes off and on which it lands in midair.

Design problems were unusually difficult and numerous. As a B-36 bomb-bay is only 16 ft long, the fighter was limited to a length of 15 ft overall. The wings, which span 21 ft, had to fold completely within the narrow space available, and had to extend in the airstream below a plane averaging 300 miles an hour at 40,000 feet. To avoid folding the tail as well as the wings, a special "X" configuration had to be developed. All the equipment of a standard fighter had to be compressed into the stubby fuselage. The plane then had to be fitted to a trapeze mechanism that would serve effectively as a "hangar" and launching platform.

The parent plane fulfills the same function as an aircraft tender in fleet aerial operations and gives new meaning to long range bomber striking forces. Not only will the XF-85 refuel while stowed in the bomb-bay of the mother plane, but it will also receive servicing such as radio and radar repair, and replenishment of oxygen.

A high altitude interceptor with speeds comparable to other jet fighter aircraft, the XF-85 is powered by a single Westinghouse J-34 engine.

hydrogenation demonstration plant at Louisiana.

High-octane gasoline will be the main product of the new facility. Unleaded octane rating of the synthetic will range from 75 to 87 points. Depending upon the by-products, the gasoline will cost from 8 to 14 cents a gallon—present fuel, made from petroleum, costs about 9 cents a gallon. Initial production capacity will be in the neighborhood of 300 barrels a day. Facilities will in time be expanded.

Diesel fuel, tailor-made for the special train trip, was made during a test run of the new plant. The cetane value of this fuel was found to be 57.7, seven points over the normal diesel oil rating. Because of this higher cetane rating, the synthetic gave the engine slightly better starting power than the natural product, according to Bureau of Mines Engineers.

The new plant is one of three being installed at Louisiana at a cost of approximately $15,000,000. Each plant will have a different process and raw material for manufacture of synthetic liquid fuels. One utilizes coal hydrogenation, one retorts oil shale and the third uses the German developed Fischer-Tropsch gas synthesis process.

Specifications of the fuel used in the locomotive were: Gravity (A.P.I.), 38.5; viscosity at 100 F, 33.5; flash, 196 F; and pour point, 10 Fahrenheit.

Prominent Scientist Director of McGraw-Hill

DR. KARL T. COMPTON has been elected a director of the McGraw-Hill Publishing Company. As Chairman of the Research and Development Board of the National Military Establishment; until recently President and now Chairman of the Corporation of the Massachusetts Institute of Technology, he is an outstanding scientist.

McGraw-Hill Magazines To Be Microfilmed

THE MCGRAW-HILL PUBLISHING COMPANY has entered into an agreement with University Microfilms, Ann Arbor, Michigan, to make available to libraries fifteen of the McGraw-Hill industrial publications in microfilm.

One of the most pressing problems facing all types of libraries today is that of providing adequate space for a constant flood of publications. Periodicals pose an especially difficult problem because of their bulk and ever-increasing numbers.

Microfilm makes it possible to produce and distribute copies of periodical literature on the basis of the entire volume in a single roll, in editions of thirty or more, at a cost approximately equal to the cost of permanently preserving material in a conventional library binding.

Under the plan, the library keeps the printed issues unbound and circulates them in that form for from two to three years, which corresponds to the period of greatest use. When the paper copies begin to wear out or are not called for frequently, they are disposed of and the microfilm is substituted.

Sales are restricted to those subscribing to the paper edition and the film copy is distributed only at the end of the volume year.

The microfilm is in the form of positive transparencies and is furnished on metal reels that are suitably labeled. All inquiries concerning the purchase of these reels should be directed to University Microfilms, 313 North First Street, Ann Arbor, Michigan.

In addition to PRODUCT ENGINEERING, the following McGraw-Hill publications will be microfilmed: *American Machinist, Business Week, Chemical Engineering, Coal Age, Construction Methods, Electrical World, Electronics, Engineering and Mining Journal, Engineering News-Record, Factory Management and Maintenance, Food Industries, Power, Textile World and Welding Engineer.*

Weldment Group Proposes Manufacturing Standards

AT A MEETING of the American Weldment Manufacturers Association held in Chicago, April 26 and 27, the Association's Committee on Manufacturing Standards and Practices presented a proposed system or method for making up a set of Manufacturing Standards and Practices to apply to commercial weldments.

The proposed system consists of five classifications established according to the service to which the weldment is to be put. These classifications are based on the quantity and quality of stresses to be encountered, such as static loading, vibration and fatigue loading. These service classifications in turn will call for a certain work quality as outlined by a set of work schedules to be carried out by the fabricator.

It was made clear by the Committee that the proposed standards would in no way circumvent or change existing accepted standards and codes now in effect in the Industry. It was pointed out that the Association's set of Manufacturing Standards and Practices, when completed, will serve the purpose of clarifying and standardizing work quality in relation to service requirements for the benefit of customer, supplier and all phases of the industry as a whole.

Society of Inventors Contacting All Patentees

THE NATIONAL SOCIETY OF INVENTORS, organized in February on a local level in Washington, now is making its bid for members nationally by a mailing to all inventors with registered patents.

The Society, founded with the object of protecting and serving the interests of the small inventor, will seek to place inventions before industrial executives who are in need of new products for their particular industries. The Society has set up a service through which it will furnish industrialists with the names of new inventions in their fields plus putting them in touch with the inventors.

Sparkplug in the organization drive of the Society is Paul E. Holbrook, a retired Army lieutenant-colonel. The Washington chapter now has 50 members and chapters are expected to be organized soon in Detroit, Pittsburgh, New York and Boston, as well as other cities.

NEW CHIEF EXECUTIVES of national societies are F. W. Walker, American Gear Manufacturers Association (left) and Horace Gooch, Jr., Society of the Plastics Industry (right). Mr. Walker is vice-president of the Philadelphia Gear Works, Inc.; Mr. Gooch is treasurer of the Worcester Moulded Plastics Company.

Experimental Techniques Emphasized At Stress Society Meeting

THE DEFINITELY GROWING TREND toward the application of experimental techniques was emphasized at the Spring meeting of the Society for Experimental Stress Analysis held in Detroit, May 19-21. In the past, the Society has centered many of the discussions around the development of instrumentation for these techniques.

An outstanding paper on the "Use of Strained Wire As A velocity Meter" was presented by C. C. Perry, of General Motors. Because mechanical velocity meters, such as pitot tubes, orifices, propellers are inherently inaccurate in measuring fluid velocities, it was decided to investigate electric meters using strain gage wire as the velocity strain gage element. The theory was that a fine wire suspended between two parallel walls of a channel in a plane normal to the axis of flow would be subjected to hydraulic drag from the passing fluid. The wire should then elongate parabolically downstream, and therefore undergo a change in resistance. The paper described an experimental setup of such a wire.

Broughton and Clark and Corten analyzed experimental strain data on curved beams having I-and T- sections. Results showed that the inner flange has a tendency to act independently of the beam as a whole, thereby invalidating the assumption that plane sections remain plane.

The strains developed in bolted joints that are loaded perpendicular to the surfaces of contact of the two members, and where no shearing forces act on the plane of contact or on the bolts, has been investigated by Dolan and McClow, of the University of Illinois. They found that a decreasing stress range and maximum stress in the bolt occurred if the bolt was replaced by one having a lower modulus of elasticity. Some equations based on simplified assumptions of the behavior were derived to provide a means of approximating stresses in the assembly.

One of the outstanding papers was presented by E. E. Weibel, University of Colorado, on the subject of "Elasticity and Friction in Toggle Systems." Many handbooks give the formula Q/P equals tan θ for the mechanical advantages of the toggle. This assumes no friction and neglects the mechanical characteristics of the system of which the toggle is a part. Mr. Weibel investigated the influence of elasticity and kinematic factors in the input and output parts. Friction was similarly investigated, and the results of the study were presented in analytical and graphical forms, suitable for the designer.

MEETINGS

July 14-15
THE MAGNESIUM ASSOCIATION—Quarterly Meeting; Hotel General Brock, Niagra, Canada.

July 20-22
PRESSED METAL INSTITUTE—National Conference; Hotel Cleveland, Cleveland, Ohio.

July 21-22
INSTITUTE OF AERONAUTICAL SCIENCES—Summer Meeting; IAS Building, Los Angeles, California.

August 15-17
SOCIETY OF AUTOMOTIVE ENGINEERS—West Coast Meeting; Hotel Multnomah, Portland, Oregon.

August 23-26
AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS—Pacific General Meeting; Fairmont Hotel, San Francisco, California.

September 12-16
INSTRUMENT SOCIETY OF AMERICA—Annual Meeting; Municipal Auditorium, St. Louis, Missouri.

September 12-16
AMERICAN SOCIETY OF MECHANICAL ENGINEERS—Industrial Instruments and Regulators Division Conference and Exhibit; Municipal Auditorium, St. Louis, Missouri.

September 13-15
SOCIETY OF AUTOMOTIVE ENGINEERS—Tractor Meeting; Hotel Schroder, Milwaukee, Wisconsin.

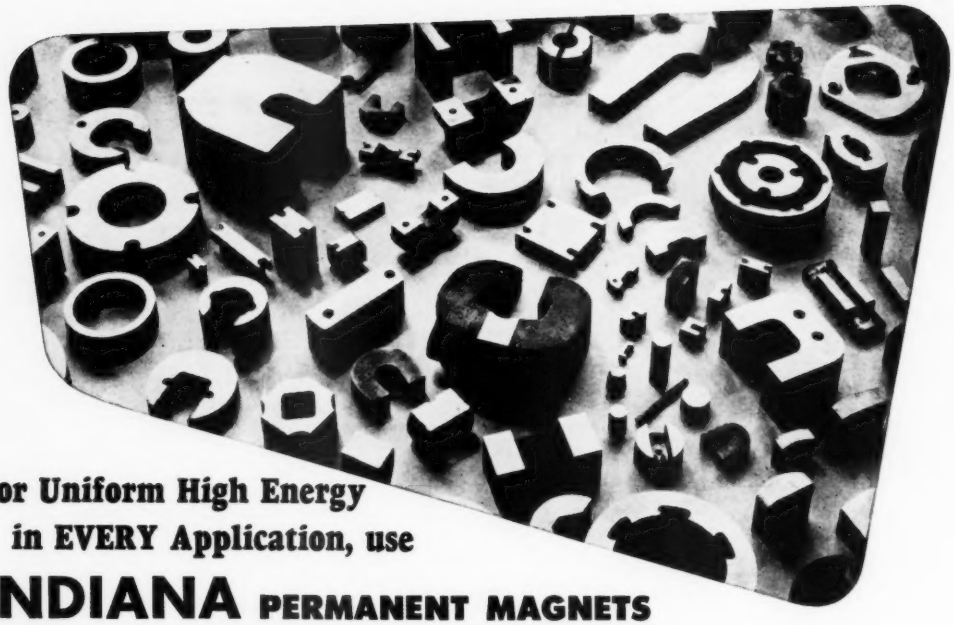
September 26-28
NATIONAL ELECTRONICS CONFERENCE; Edgewater Beach Hotel, Chicago, Illinois.

September 28-30
AMERICAN SOCIETY OF MECHANICAL ENGINEERS—Fall Meeting; Lawrence Hotel, Erie, Pennsylvania.

September 29-30
THE MAGNESIUM ASSOCIATION—Summer Meeting; Greenbrier Hotel, White Sulpher Springs, Virginia.

October 5-8
SOCIETY OF AUTOMOTIVE ENGINEERS—Aeronautic and Aircraft Meeting and Engineering Display; Biltmore Hotel, Los Angeles, California.

October 10-14
AMERICAN SOCIETY FOR TESTING MATERIALS—West Coast Meeting; Fairmont Hotel, San Francisco, California.



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Permanent magnets to deflect electrons out of the ion-electron stream. Made of Alnico and Cunife in all diameters and forms.

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Assemblies, of which the permanent magnet is a part, designed to meet your specifications. Furnished for all requirements.

● Look to INDIANA for *quality* permanent magnets—for skill in manufacture—for cost-cutting engineering aid. Strict supervision in every step of production is your assurance of exact magnetic and mechanical characteristics.

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SPECIALISTS IN "PACKAGED ENERGY" SINCE 1908

Nomogram to Determine Parallel Axis Moment of Inertia

HERBERT F. BARIFFI
Consulting Engineer

ONE METHOD of determining the moment of inertia of a mass through its center of gravity is to suspend the mass from a knife-edge. Such an arrangement, using a piece of keystock for a knife-edge, is shown in Fig. 1. If this compound gravity pendulum, which is in effect what the setup amounts to, is set swinging and the arc of swing is limited to about 6 deg double amplitude, the moment of inertia about the support axis is equal to

$$I_o = \frac{W}{4\pi^2} t^2 L \qquad (1)$$

where

I_o = moment of inertia about support axis
W = weight of mass, lb
t = oscillation period, sec
L = distance between center of gravity and support axis, in.

To find the moment of inertia about center of gravity the following equation can be used.

$$I_{cg} = I_o - L^2 \frac{W}{g} \qquad (2)$$

where

g = acceleration of gravity, ft per sec^2

Substituting I_o value from Eq (1) into Eq (2)

$$I_{cg} = \frac{W}{4\pi^2} t^2 L - L^2 \frac{W}{32.2 \times 12}$$

Simplifying

$$I_{cg} = WL[0.02533\, t^2 - 0.002588L] \qquad (3)$$

This Eq (3) will give values of I_{cg} in in. lb sec^2.

The nomogram illustrated can be used to solve for I_{cg} with values of t, L and W known. To use this nomogram start with a value t on the inner left-hand A scale, pass through a value of L on the A curve to the right-hand, or turning axis. Then, follow a straight line from the turning point through a value of W on the A diagonal, and return to the left-hand axis, reading I_{cg} on the outer scale. By using the right-hand I and t scales, and working to the left over the B curve for L, the same problem can be solved with larger values of t.

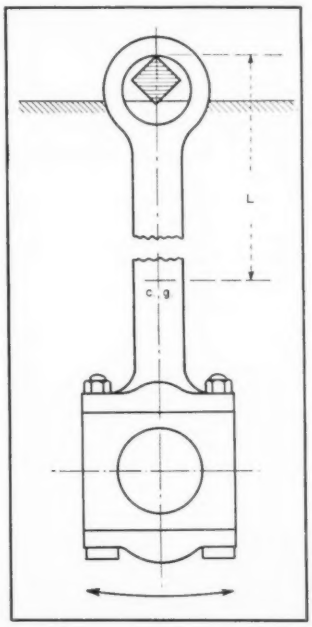


Fig. 1—Connecting rod suspended from keystock.

EXAMPLE: Given a pulley of 8 lb weight, L equals 10 in., t equals 1.5 sec. Find I_{cg}.

SOLUTION: Starting at t equals $1\frac{1}{2}$ on inner A scale of left-hand axis, follow the dotted line through curve A at L equals 10 to the turning line; go back through W equals 8 on diagonal A to I_{cg} equals 2.5 in. lb sec^2.

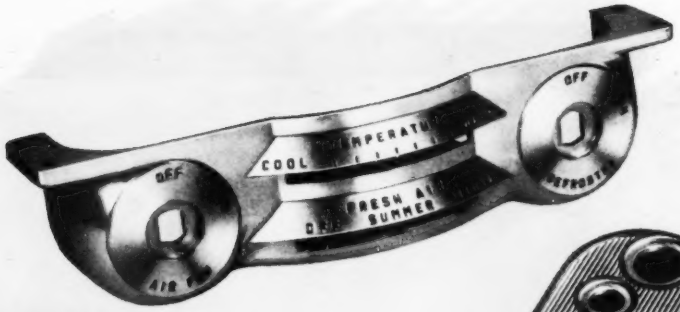
It should be noted that the effects of L and t are screened in the equation. However, I_{cg} is directly proportional to W, and this fact permits the unlimited extension of the nomogram's use.

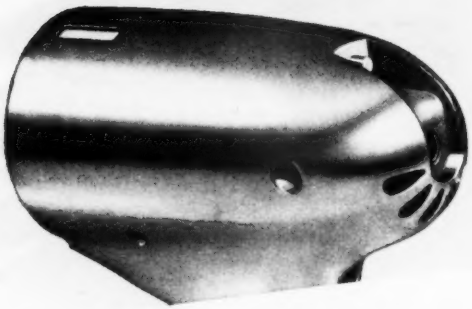
Suppose, in the above example, W had been 880 lb. It would appear that this value is too large for the W scale, but Eq (3) can be written:

$$\frac{I_{cg}}{k} = \frac{WL}{k}[0.02533t^2 - 0.02588L]$$

So, in this case, assume k equals 110, and use the nomogram as above with W equaling 8, and read I_{cg}/k equals 2.5. Now merely multiply this value by 110 to find 275 in. lb sec^2. This is the true value of I_{cg}.

An unusual feature of this nomogram is the relation between the values of t and L; these quantities cannot be assumed at random for trial of nomogram accuracy. For example, a scant passing through $t = 1.81$ and $L = 30$ also passes through $L = 2$, thus suggesting that two different suspension lengths will satisfy the same result. One of these lengths is an extraneous value as the previously outlined experiment will indicate. Furthermore, t is always larger than $0.31936\sqrt{L}$ when inch and second units are used.





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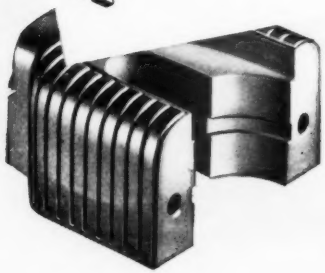

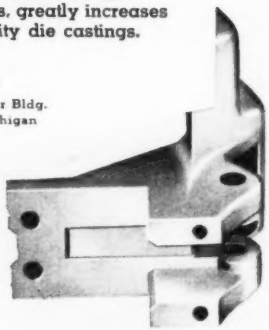

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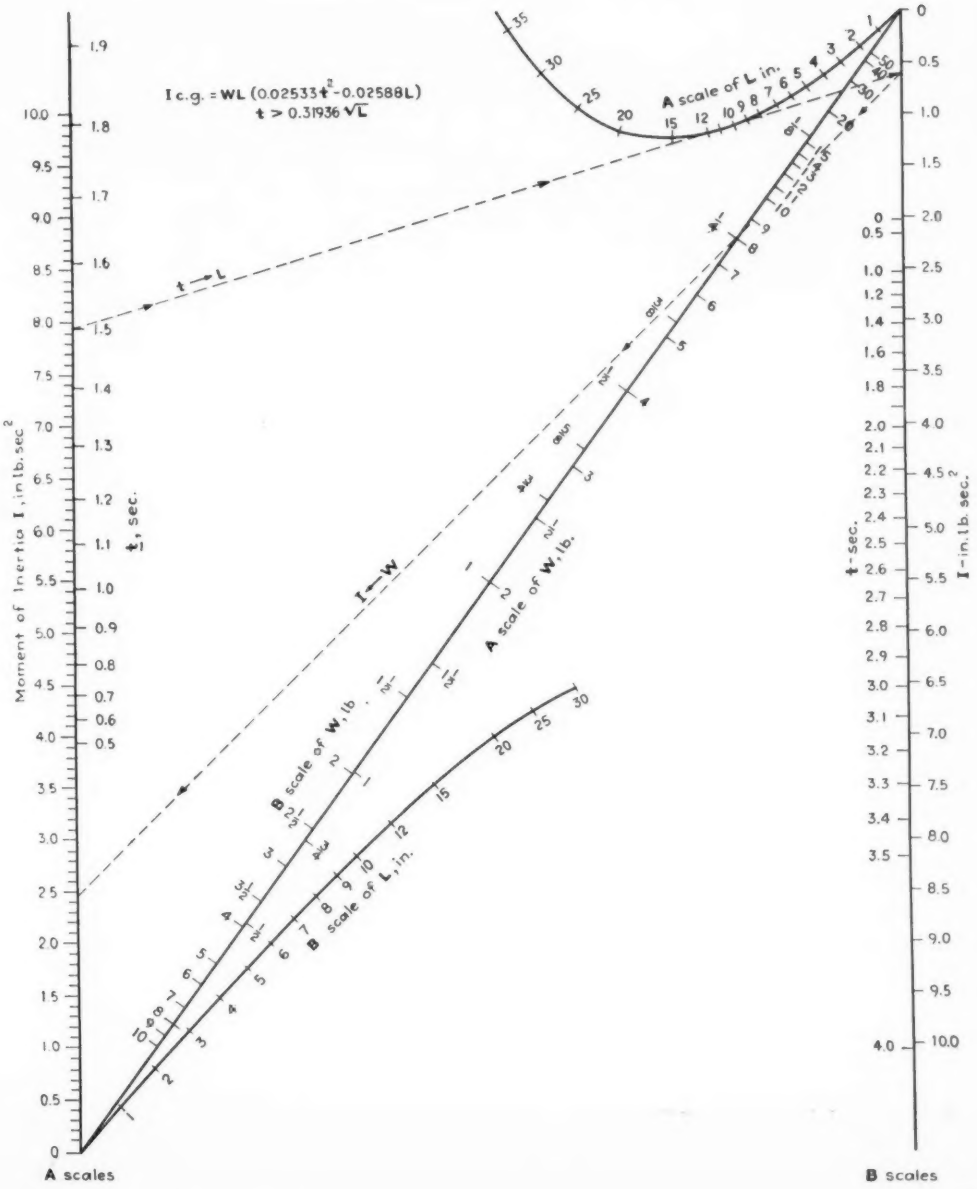
Nomogram to Determine Parallel Axis Moment of Inertia (continued)



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Corrosion Guide for Fasteners

H. M. HARPER COMPANY

WHEN EVALUATING MATERIALS from the standpoint of corrosion resistance, the physical form in which the material is to be used must always be considered. The ratings in the accompanying chart are all based on the assumption that the metals listed will be such holding members as screws, bolts, studs, and the like. Thus, the materials would be rated differently if used for tanks, pumps, or valves.

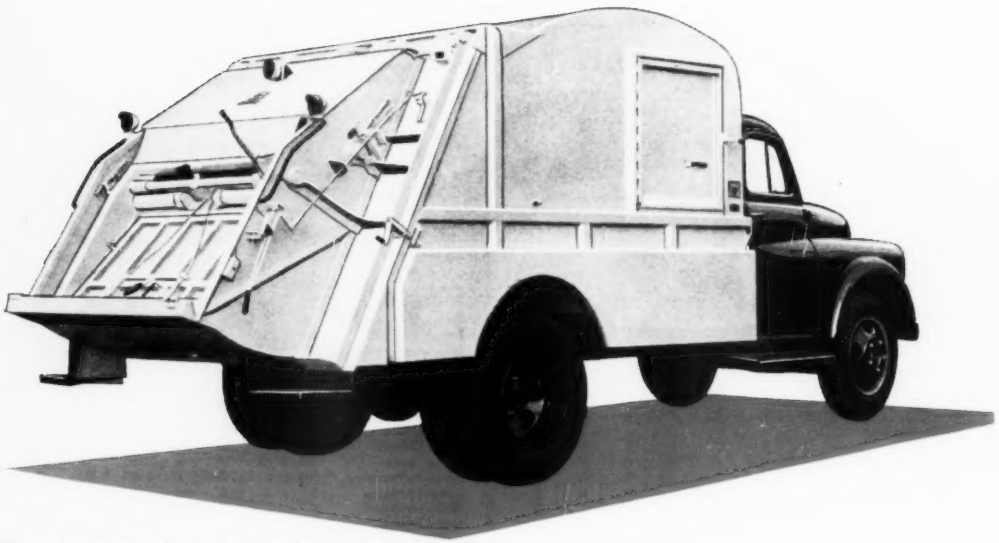
Although many liquids which may come in contact with fasteners are listed below, it is important to remember that no condensation of data such as this can give complete accuracy. Consequently, this table should only be used as a guide to the selection of proper fastener metal.

KEY: E-excellent G-good F-fair NG-no good See end of table for key to numbers

	Brass and Naval Bronze	Silicon Bronze	Monel Metal	Stainless Types 410, 416 and 430	Stainless Types 302, 303, 304 and 308	Stainless Type 316	Copper
Acetate Solvents, Crude	F	G	G	G	E	E	G
Acetic Acid, (Crude)	F	G	G	NG	G	E	G
Acetic Anhydride	NG	G	G	NG	G	E	G
Acetone	E	E	E	E	E	E	E
Acetylene	(1)	NG	G	E	E	E	NG
Alcohols	G	E	E	E	E	E	E
Aluminum Sulfate	F	G	G	NG	F	G	G
Ammonia Gas	NG	(2)	(2)	E	E	E	(2)
Ammonium Chloride	F	G	E	F	F	E	G
Ammonium Hydroxide	NG	NG	F	E	E	E	NG
Ammonium Nitrate	NG	F	F	E	E	E	F
Ammonium Phosphate (Neutral)	F	F	G	G	E	E	F
Ammonium Phosphate (Acid)	F	F	G	F	G	E	F
Ammonium Sulfate	F	F	G	G	E	E	F
Asphalt	G	E	E	G	E	E	E
Beet Sugar Liquors	G	E	E	G	E	E	E
Benzene or Benzol	E	E	E	E	E	E	E
Benzine	E	E	E	E	E	E	E
Borax	G	G	E	E	E	E	G
Boric Acid	F	G	E	F	G	E	G
Butane, Butylene, Bitadiene	E	E	E	E	E	E	E
Calcium Bisulfite	NG	G	NG	NG	G	E	G
Calcium Hypochlorite	F	F	F	NG	F	G	F
Carbon Dioxide (Dry)	E	E	E	E	E	E	E
Carbon Dioxide (Wet)	F	G	G	E	E	E	G
Carbon Disulfide	F	NG	F	G	E	E	NG
Carbon Tetrachloride	E	E	E	E	E	E	E
Chlorine (Dry)	G	G	E	G	G	G	G
Chlorine (Wet)	NG	F	F	NG	NG	F	F
Chromic Acid	NG	NG	F	F	G	E	NG
Copper Sulfate	NG	F	F	E	E	E	F
Ethers	E	E	E	E	E	E	E
Ethyene Glycol	G	E	E	E	E	E	E
Ferric Chloride	NG	NG	NG	NG	NG	NG	NG
Ferric Sulfate	NG	F	F	E	E	E	F
Formic Acid	F	G	G	NG	G	E	G
Freon	E	E	E	E	E	E	E
Gasoline (Refined)	E	E	E	E	E	E	E
Glucose	E	E	E	E	E	E	E
Glycerine or Glycerol	G	E	E	E	E	E	E
Hydrochloric Acid	NG	F	F	NG	NG	NG	F
Hydrocyanic Acid (Hydrogen Cyanide)	NG	NG	G	F	E	E	NG
Hydrofluoric Acid	F	F	E	NG	NG	NG	F
Hydrogen Fluoride	F	G	E	F	G	G	G
Hydrogen	E	E	E	E	E	E	E
Hydrogen Peroxide	NG	F	G	E	E	E	F
Hydrogen Sulfide (Dry)	F	NG	F	G	E	E	NG
Hydrogen Sulfide (Wet)	F	NG	F	F	G	E	NG
Lacquers and Lacquer Solvents	F	E	E	E	E	E	E
Magnesium Chloride	F	G	E	F	G	E	G
Magnesium Hydroxide	G	E	E	E	E	E	E
Magnesium Sulfate	G	E	E	E	E	E	E
Mercuric Chloride	NG	NG	NG	NG	NG	F	NG
Natural Gas	G	E	E	E	E	E	E
Nickel Choride	NG	F	G	NG	F	G	F
Nickel Sulfate	F	G	E	F	G	E	G
Nitric Acid	NG	NG	NG	G	G	G	NG
Oleic Acid	F	G	E	G	G	E	G
Oxalic Acid	F	G	E	F	G	E	G
Oxygen	E	E	E	E	E	E	E
Palmitic Acid	F	G	E	G	G	E	G
Petroleum Oils (Sour)	F	NG	NG	F	E	E	NG
Petroleum Oils (Refined)	E	E	E	E	E	E	E
Phosphoric Acid 25%	NG	G	G	NG	F	E	G
Potassium Chloride	F	G	E	F	G	E	G
Potassium Hydroxide	NG	F	E	E	E	E	F
Potassium Sulfate	G	E	E	E	E	E	E
Propane	E	E	E	E	E	E	E
Shellac	G	E	E	E	E	E	E
Soda Ash (Sodium (Carbonate)	G	G	E	E	E	E	E
Sodium Bicarbonate	E	E	E	E	E	E	E
Sodium Bisulfate	F	G	E	NG	NG	E	G
Sodium Chloride	F	G	E	F	G	E	G
Sodium Cyanide	NG	NG	G	E	E	E	NG
Sodium Hydroxide	NG	F	E	E	E	E	F
Sodium Nitrate	F	G	E	E	E	E	G
Sodium Perborate	F	G	E	E	E	E	G
Sodium Peroxide	F	G	E	E	E	E	G
Sodium Phosphate (Alkaline)	F	G	E	E	E	E	G
Sodium Phosphate (Neutral)	G	E	E	E	E	E	E
Sodium Phosphate (Acid)	F	G	E	NG	G	E	G
Sodium Silicate	F	G	E	E	E	E	G
Sodium Sufate	G	E	E	E	E	E	E
Sodium Sulfide	NG	NG	G	E	E	E	NG
Sludge Acid	NG	G	G	NG	NG	F	G
Sulfur	NG	F	F	E	E	E	F
Sulfur Chloride	NG	NG	G	NG	F	G	NG
Sulfur Dioxide (Dry)	F	E	E	E	E	E	E
Sulfur Dioxide (Wet)	NG	G	NG	NG	G	E	G
Sulfuric Acid 10%	NG	G	G	NG	NG	G	G
Sulfurous Acid	NG	G	NG	NG	F	G	G
Toluene or Toluol	E	E	E	E	E	E	E
Turpentine	F	E	E	G	E	E	E
Varnish	G	G	E	E	E	E	G
Vegetable Oils	G	G	E	E	E	E	G
Water (Fresh)	F	G	E	E	E	E	G
Water (Salt)	F	G	E	F	G	G	G
Zinc Chloride	NG	G	E	NG	NG	G	G
Zinc Sulfate	F	G	E	F	G	E	G

Notes: (1) Alloys containing up to 60 percent copper acceptable; high copper alloys not acceptable.
(2) Apparently resistant to dry gas at ordinary temperatures; attacked rapidly by hot and moist gas.

another use for N-A-X HIGH-TENSILE STEEL



The modern Gar Wood Load & Packer for garbage and rubbish.

The high corrosion-resistance and durability of N-A-X HIGH-TENSILE makes it ideal for use in garbage disposal trucks and similar applications. Another reason why industry is rapidly changing to N-A-X HIGH-TENSILE.

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NEW MATERIALS AND PARTS

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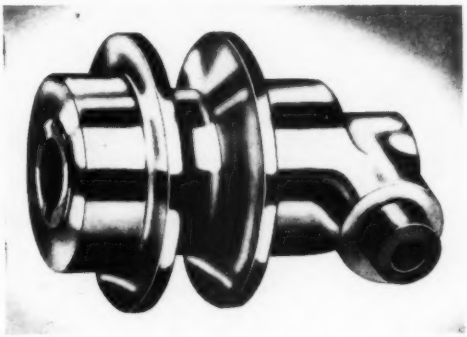
V-Belt Clutch

Congress Drives Div., Tann Corp., 3750 *E. Outer Drive, Detroit* 34, *Mich.*

New clutch consists of a split pulley, the flanges of which can be separated or closed by a flick of the finger. When the flanges are separated the belt rests on a sleeve between them, without motion or friction. The load is picked up gradually, allowing the use of a smaller electric motor or gasoline engine than would have to be used with a

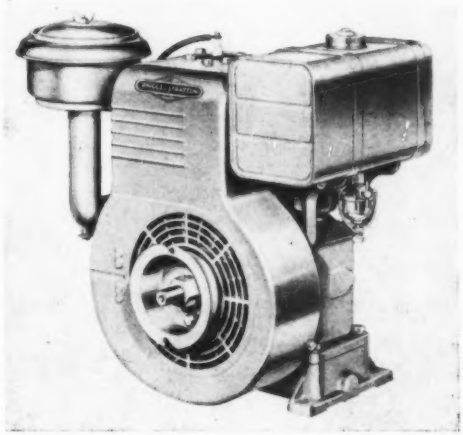


high initial torque. Clutch is available in four sizes for "A" belts, covering outside diameters from 2.5 to 4 in. and pitch diameters from 2.35 to 3.85 in. Four sizes for "B" belts include outside diameters from 2.5 to 4 in. and pitch diameters from 2.2 to 3.7 inches. The overall length of all models is 3.25 inches.

Gasoline Engines

Briggs & Stratton Corp., Milwaukee, Wis.

New models, Nos. 9, 14 and 23, are 4-cycle, air cooled, gasoline engines rated at 2.16 to 3.1, 3.56 to 5.1 and 6.5 to 8.25 hp, respectively. Engines are available with either plain or ball main bearings and have an inclosed

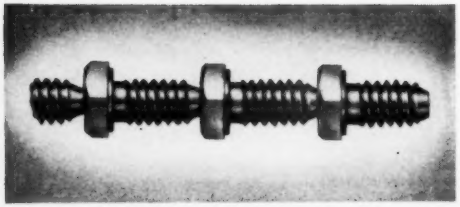


adjustable governor which operates in oil. A new vacuum breather and spring loaded oil seals prevent oil leaks. A new feature, the Magnematic ignition system, consists of a breaker box unit externally mounted on the crankcase and containing breaker points, condenser, manual stop switch, and remote stop switch terminal. This system provides high voltage at low speeds, together with an automatic spark retard and advance, giving the engine easy starting characteristics.

Small, Quick Seating Screws

American Screw Co., Providence 1, *R. I.*

Screwstick is a one piece stick of identical small screws which are seated by pneumatic, electrical, spiral, or hand-rachet drivers and then twisted off. Screws are twisted off automatically and the fastening made when predetermined torque is reached. Then as a tightened screw is freed from the neck, the next screw in line is automatically advanced. Amount of torque is controlled by

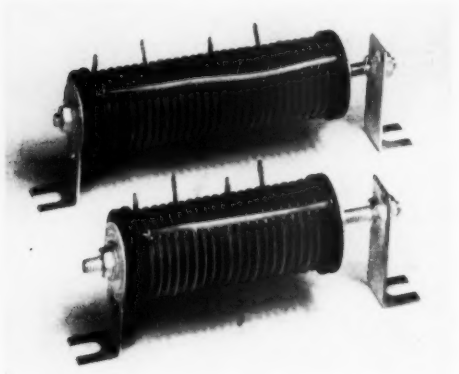


the cross-sectional area of the neck joining screws. The head of the driven screw is burnished smooth by the next screw to be driven. These screwsticks are available in Nos. 0, 1, 2, 3, 4 and 5 dia in mild steel, brass, and aluminum.

High Voltage Selenium Rectifier Cell

General Electric Co., Schenectady 5, N. Y.

New high-voltage selenium rectifier cell, designed to permit the use of a smaller stack to achieve the same wattage, is rated at 18 v d-c output, a 50 percent increase over low-voltage cells. The new high-voltage cell can be

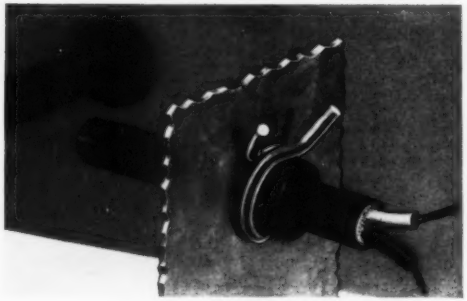


used in rectifier stacks for installations where space is limited and where the stack will not be required to operate continuously 24 hr daily for long periods. An evaporation process which provides a uniform coating of selenium on each cell assures uniform operation in electrical equipment requiring d-c power. Illustration shows the saving in space when new cell is used.

Sealing Material

Felt Products Mfg. Co., 1508 Carroll Ave., Chicago 7, Ill.

Felseal can be applied to any fibrous-type base material in film thicknesses of 0.001 to 0.005 in. This modified polysulphide elastomeric coating is not materially affected by mineral or vegetable oils, fats or soaps, aliphatic and aromatic hydrocarbons, lower alcohols, carbon tetrachloride, or dilute acids and bases. It is especially suited for use as a sealer for transmissions, differentials, carburetors, gear housings, timing case gaskets, and other applications where high temperatures, extreme cold, gases or solvents may create a sealing problem. Base materials, such as chipboard, treated paper and fiber, are furnished in 0.010 to 0.125 in. thicknesses.



Grommet Clamp

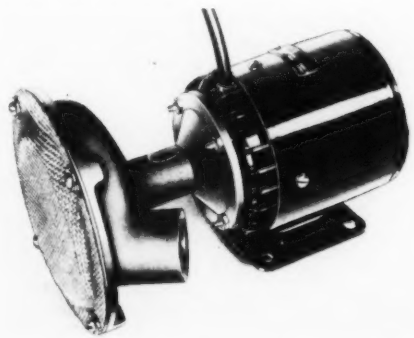
Sterling Enterprises, Inc., Berlin, Conn.

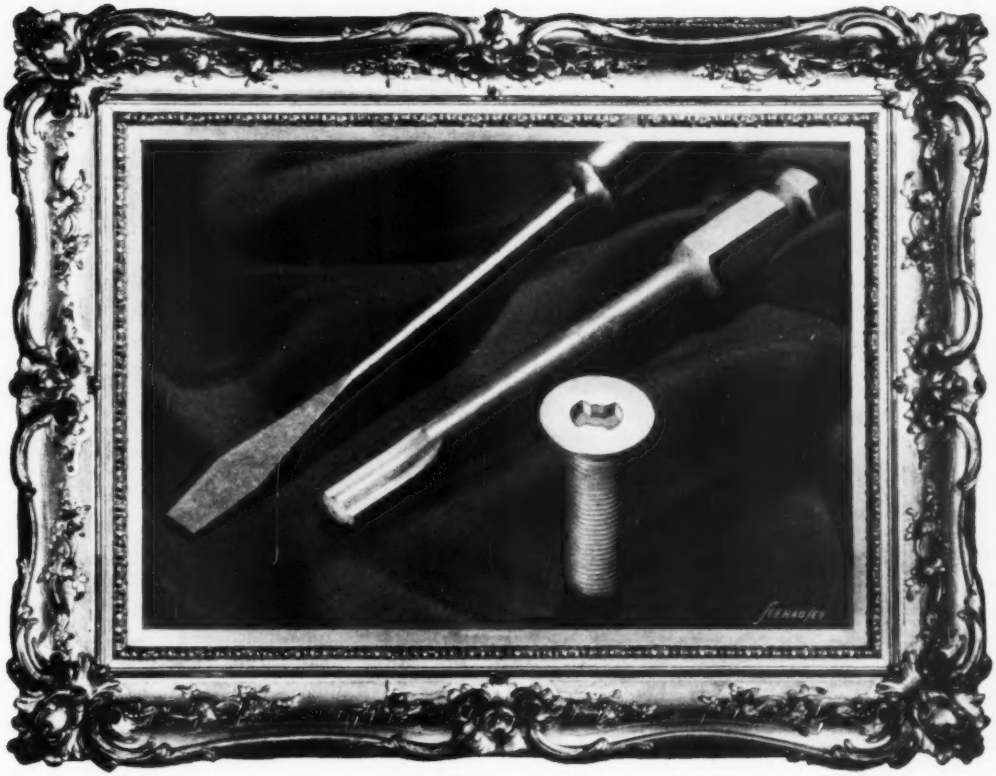
This new clamp fits over the neck of a resilient grommet or bushing and exacts an even pressure on the grommet, which, in turn, clamps the material in its walls. A rubber cable held by a grommet clamp is not distorted in any way, and may be reused any number of times. The clamp is one piece, and is shaped from rounded stock to eliminate sharp edges. It has a strong grip that will withstand a direct pull generally in excess of the weight of the article to which it is attached.

Small Centrifugal Water Pump

Thompson Products, Inc., Cleveland 17, Ohio.

Powered with a 1/25 hp motor, the pump is capable of circulating water or other coolants in refrigeration, air conditioning, ventilating, and other applications where flows at low pressures are required. The pump body and impeller are machined from brass castings, the inlet cover plate is a brass stamping, and the impeller is mounted directly on an extended stainless steel motor shaft. These non-corrosive materials make the pump completely rust proof. Available for 115 or 230 v, 50 or 60 cycle a-c, and 115 or 230 v direct current.





Acclaimed a Masterpiece...

CLUTCH HEAD *Brightens the Profit Picture with 15% to 50% Assembly Increases*

Here is how CLUTCH HEAD'S modern design meets today's competitive selling problem of "*How to Produce More for Less*"...by effecting time and cost savings that quicken production steps all the way down the assembly line.

High Visibility of the roomy recess presents an easy-to-hit target. "Green" operators require no break-in. They drive with speed and confidence that checks out slow-down hesitation.

Chewed-up Heads Eliminated because dead-center entry with the Center Pivot Column prevents driver canting and makes straight driving automatic.

Safe Non-tapered Driving eliminates the danger of driver skidding from "ride-out" as set up by tapered driving . . . an important safety factor for the protection of manpower and material.

Zero in Skid Damage is reported by CLUTCH HEAD users. The all-square contact of the straight-sided driver with the straight-walled recess makes high torque driving almost effortless.

A Fatigue Factor Disposed Of. Absence of end pressure means safer, faster, easier driving. No end-of-the-shift lag means more screws driven for higher production.

Up to 214,000 Screws Driven non-stop by the Type "A" Bit . . . without interruption for tool change or reconditioning. Add to this record performance the fact that a 60-second on-the-spot operation restores this bit to original efficiency . . . *repeatedly*.

The Lock-On Overcomes Fumble Spots. A reverse turn of the bit in the recess forms a frictional hold that unites screw and bit as a unit. This permits quick, easy one-handed reaching to inner spots.

Speeds Field Service Too. With the Type "A" Hand Driver, field service men find it easy to withdraw "frozen" screws undamaged and safely held by the Lock-On on the end of the bit for re-use.

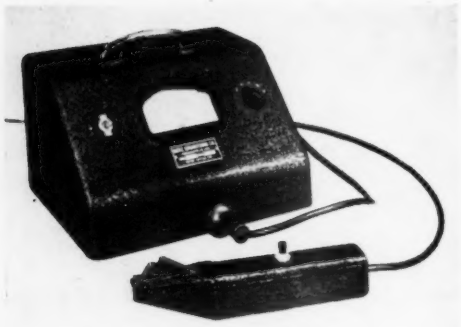
Common Screwdriver Operation. This is the *ONLY* modern screw with a recess basically designed for operation with a flat blade . . . which need only be reasonably accurate in width. Important to simplified field service.

CLUTCH HEAD SCREWS

These highlights of America's Most Modern Screw are fully detailed and illustrated in the NEW CLUTCH HEAD BROCHURE. *Send for your copy and indicate the sizes and types of screws that interest you.*

UNITED SCREW AND BOLT CORPORATION

CLEVELAND 2 CHICAGO 8 NEW YORK 7



Electronic Comparator

Merz Engineering Co., Indianapolis, Ind.

Merz Pico Surface Comparator electronically checks surface of machine parts against an approved sample. The instrument is portable and needs no accessory equipment or skilled operator; weighs 15 lb and operates from 110 v, 60-cycle outlet. Readings are taken by pressing head against surface to be checked, touching actuating button and comparing meter reading against master reading. The area of exploration is some 500,000 times greater than with tracer methods, and work is not scratched.

Graphite Filled Nylon

The Polymer Corp., Reading, Pa.

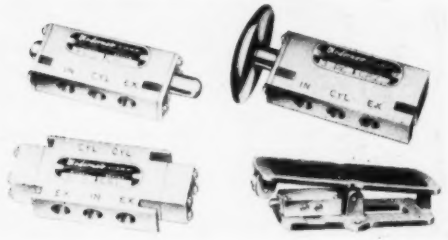
Called "Nylatron G," new graphite-filled nylon is available in the form of rods, strips and cylinders. The new material has better wear resistance and frictional properties than unfilled nylon, and is useful where a combination of rubbing and impact is involved, or where normal lubrication is impossible. Well suited for use as dry bearings, it can also be used for cams, cam followers,

gears, washers, oil seal rings and valve and pump packing. It is available in a range of rod diameters from 0.100 to 2¾ in. Sizes of cylinders range from 2 to 7 in. OD with varying wall thicknesses, and in strips from 0.010 to 0.090 thick, and up to 2 in. width.

Pilot Valves

Modernair Corp., 4222 Hollis St., Oakland, Calif.

Designed for use in pneumatic or fluid operating circuits, the three or four-way ⅛ in. port size CRV valve can be used for remote control of single or double acting air devices. It can be installed as a two-way valve by plugging one of the ports in the three-way model. The construction features the use of "O" ring seals, which are replaceable without disturbing piping connections. Also, new housing design incorporates an end-plate which secures the piston rod and prohibits the plunger coming out during installation or in operation.



Odorless, Tasteless Rubber

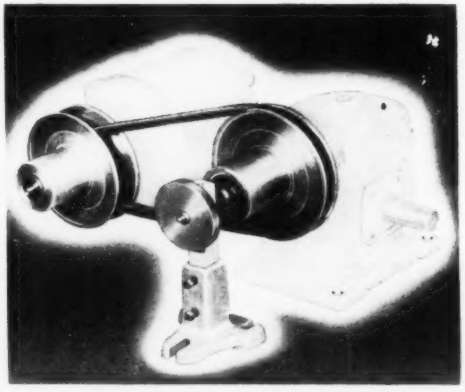
The Stalwart Rubber Co., 166 Northfield Rd., Bedford, Ohio.

This gum-based natural rubber compound is odorless, tasteless, and chemically pure under Pure Food & Drug Act specifications. It is for all types of food and chemical processing applications which require extreme purity of all materials coming in contact with the product. The compound withstands prolonged heat to 225 F and up to 250 F for limited periods. It will not become brittle and crack at 0 F. Products fabricated from the compound can be molded, extruded, die-cut or lathe-cut into almost any shape. Tolerances can be held to practical accuracy.

Variable Speed Control

Speed Selector, Inc., 118 Noble Court, Cleveland 13, Ohio.

New assembly includes two variable pitch sheaves and control. A spring-loaded sheave is mounted on the motor shaft while the control sheave is mounted on the driven shaft. A regulating mechanism consisting of a



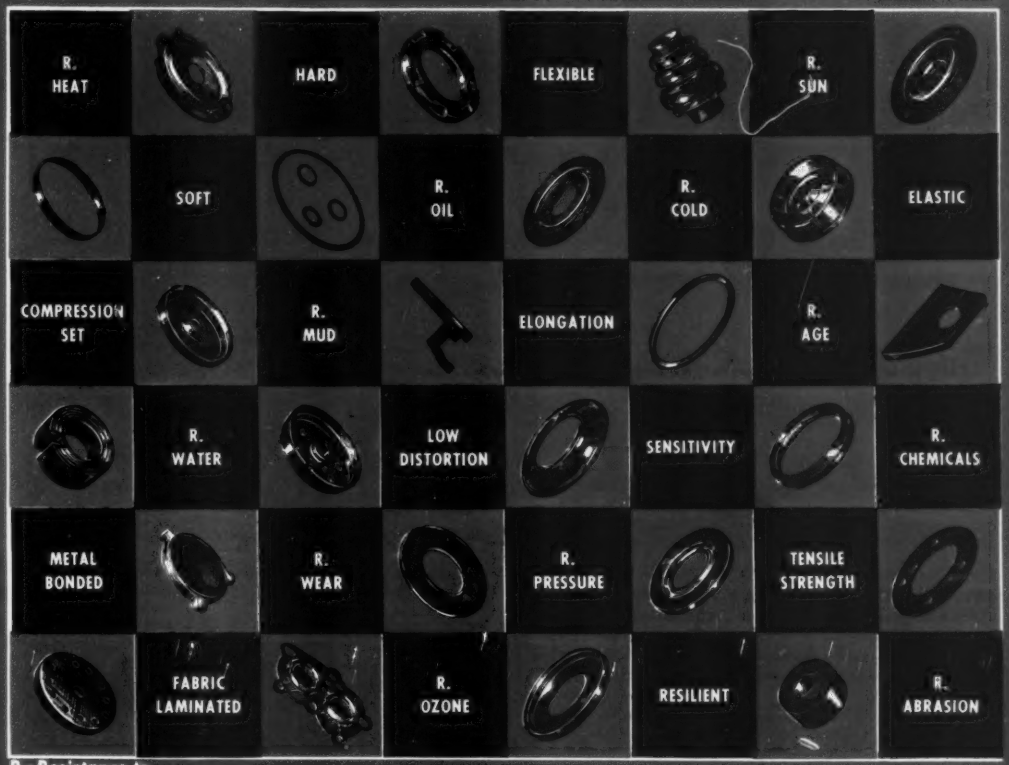


CHART FOR THE IMPOSSIBLE

To figure out all the conceivable ways that physical characteristics, design variations and resistance properties can be combined in Sirvene parts would be nearly impossible. And a great waste of your time, because only *one* combination will do the job for you. Sometimes even that combination seems impossible—and that's when you need the help of Sirvene engineers. Taking your specific performance requirements, they'll assist you in perfecting the design, then work out the proper combination of oil-resistant elastomers, do the developmental work and produce the parts in quantity under strict laboratory control. You can depend on uniform quality and micrometric accuracy in every part. When you are in a tough spot for the right flexible part to do a critical mechanical protection or sealing job—and to keep on doing it under rough service conditions—call on Sirvene.

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PERFECT Oil Seals
SIRVIS Mechanical Leather

Sirvene products include diaphragms, boots, gaskets, oil seals, washers, packings, and other special molded mechanical pliables.

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1299 Elston Avenue, SIRVENE DIVISION Chicago 22, Illinois

SIRVENE

THE *SCIENTIFIC* COMPOUNDED ELASTOMER

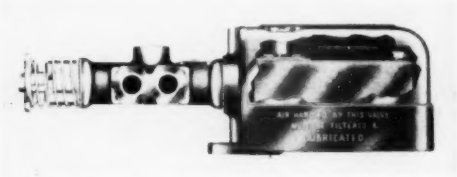
Portland • Syracuse • Peoria

hand wheel and bracket, adjustable to any application, opens and closes the control sheave. The changes in pitch diameter cause the standard V-belt to actuate the spring-loaded motor sheave, thus giving stepless speed control over a 6:1 range. Remote control can be applied. The drive may be used with motors up to one horsepower.

Solenoid Air Valves

Valvair Corp, 454 Morgan Ave., Akron 11, Ohio.

This line of single-solenoid valves has a one-piece bronze base, powerful solenoid for positive seating and cool operation, a heavy sheet metal cover, "OU" type packer and shock-resisting clevis and clevis pin. It handles fil-

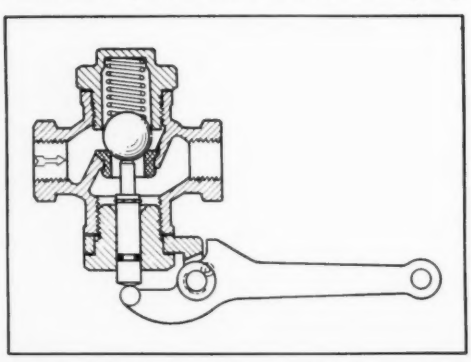


tered and lubricated air with a pressure of 0 to 125 psi. Sizes offered are $\frac{1}{4}$, $\frac{3}{8}$, and $\frac{1}{2}$ in., with all sizes available for 110, 220, and 440 v in both 50-60 cycle and 25 cycle current. Both 2 and 3 way open end exhaust, and 3 and 4 way piped exhaust models are offered in all sizes.

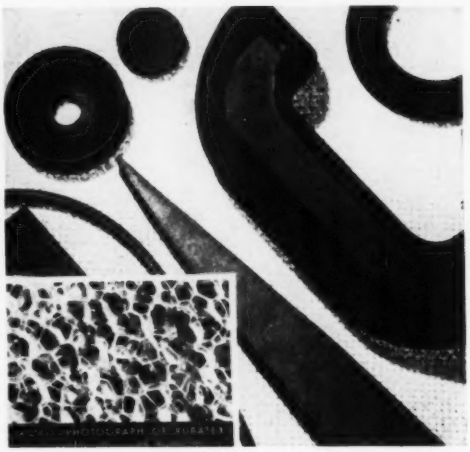
Air, Water Valve

Leslie Co., 345 Delafield Ave., Lyndhurst, N. J.

Valve is suitable for use with air, water, and other fluids of a non-corrosive nature up to 200 psi and 150 F for air and 180 F for water. It has a ball valve which closes tight with inlet pressure and will not collect dirt or other foreign matter. The steam is sealed by an O-ring not accessible to tampering or adjustment and eliminates a stuffing-box. The body is semi-steel, and has screwed connections of $\frac{1}{2}$ in. size which can be bushed to $\frac{1}{4}$ or $\frac{3}{8}$



inch. The valve is adjusted for control of pneumatic cylinders on lifts, hoists, presses, etc., as a small valve for general service in shops, for control of flushing liquids and other such uses.



Closed-Cell Expanded Rubber

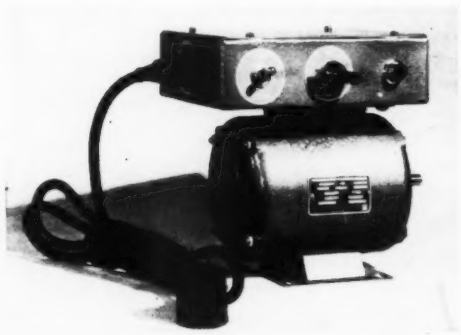
Rubatex Div., Great American Ind., Inc., 230 Park Ave., New York 17, N. Y.

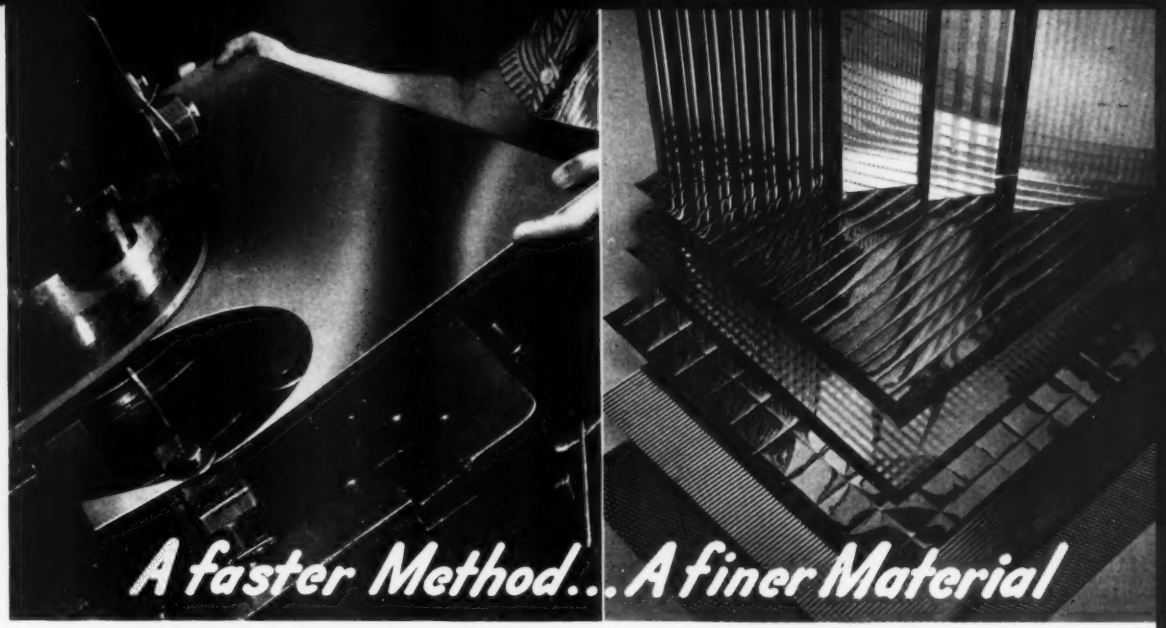
Unlike sponge rubber, in which air spaces are interconnected, Rubatex gas-expanded closed-cellular rubber has each nitrogen-filled cell completely encased. Because there is no escape of the nitrogen, the material is resilient. buoyant, and does not conduct heat or absorb water. Elasticity of rubber and compressibility of nitrogen give good shock absorbtion and make material useful for packing of fragile products, damping of vibration, impact fenders, weather stripping, expansion joint fillers, gaskets, refrigeration equipment, and electrical insulation. Material can be molded, die-cut, stamped, split, cemented, or formed by other conventional methods. Comes in sheets up to one in. thick, in natural or synthetic rubber.

Synchronous Motor

Electric Indicator Co., Stamford, Conn.

Model GH-371 hysteresis-type motor provides three synchronous speeds in one unit. Operation is switch-controlled (or can be relay-controlled) and provides for clockwise or counter-clockwise rotation. It is reversible





MORE ECONOMICAL TOO, because Nickeloid Metals require no plating, polishing or other finishing.

LUSTROUS FINISHES, a variety of metals, patterns add beauty, sales appeal to a product.

Redesigning with Nickeloid Metals to Lower Production Costs

By CARL C. STRUEVER

Gen. Mgr., American Nickeloid Company
Peru 4, Illinois

NICKELOID METALS offer the product designer two important weapons in his war on costs: First, a production *method* that lowers fabricating costs by eliminating plating, polishing. Second, a lustrous, appealing material that increases product salability — thus helping sustain the high sales volume needed for low-cost, mass manufacturing. These opportunities are present wherever bright metal can be used either functionally or as trim.

The Production Savings

NICKELOID METALS are a "*finished*" raw material. They are pre-plated, ready for fabrication and assembly without further finishing. Plating operations are eliminated. Operations involving cleaning, buffing, polishing are eliminated. This means reduced production hours, smaller equipment needs, less storage and working space, small in-process inventories. Nickeloid Metals are always ready for immediate fabrication, in sheets or coils. The coils are available in widths from 1/8" to 24" for continuous feeding to high speed, automatic machines. Fabrication can move swiftly from raw material to finished product.

The Fabrication Techniques

The highly polished finishes of NICKELOID METALS are not marred by any normal fabricating operation — blanking, drawing, stamping, riveting, spot welding, soldering, etching. Where more severe fabrication is planned, the designer can in many cases still use a NICKELOID METAL.

Both sheets and coils can be provided with a special "Mar-Not" protective coating — a pressure sensitive paper, or a plastic film, that protects the finish during fabrication, then peels off easily and quickly.

A Variety of Metals

NICKELOID METALS are platings of Chromium, Nickel, Brass or Copper to such base metals as Steel, Zinc, Brass, Copper or Aluminum. Some 17 different Nickeloid Metals are available, each developed to meet certain specific design requirements — beauty, durability, rigidity, heat-resistance, pliability, corrosion or rust resistance, cost considerations. From this wide range of metals the designer can select one which meets his exact needs.

Inspirational Patterns

The designer will find among his NICKELOID METAL samples a range of metals, patterns and finishes that is truly inspirational. These lustrous, eye-catching patterns can add a touch of beauty and distinction to even a purely functional application . . . can give a product the richness, the sparkle needed for success at point of sale.

"Sampler" for Designers

Available on request are complete studies on the properties, applications and latest fabrication techniques for NICKELOID pre-plated METALS, including a complete variety of metal samples. Manufacturers are invited to write for these portfolios as an aid to designing for lower production costs and increased product salability.

AMERICAN Nickeloid COMPANY – Peru 4, Illinois

while running, and can be changed from one speed forward to a different speed reverse. Rated at 1/100, 1/60, and 1/40 hp at 900, 1,800, and 3,600 rpm, respectively. It operates from 115 v, 60 cycle, single-phase alternating current. Dimensions of motor are $4\frac{5}{8}$ in. dia and $5\frac{7}{8}$ in. in length, excluding shaft.

Small Servo Motors

Square D Co., Kollsman Instrument Div., 80-08 45th Ave., Elmhurst, N. Y.

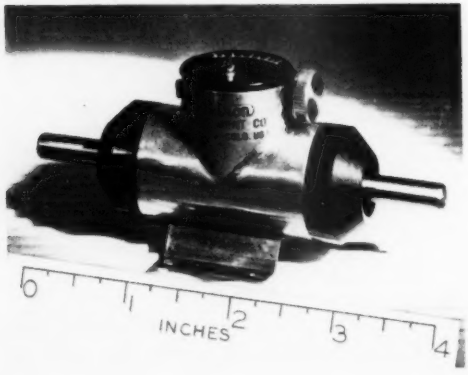
New a-c servo motor gives high torque, high speed, low inertia, small size and light weight. This 400 cycle, 115 v, two phase, four pole induction motor has a torque to inertia ratio of 26,300 radians/sec/sec. Therefore it is

possible for the motor to reverse fully in two-tenths sec from 11,200 rpm. It delivers $2\frac{1}{2}$ oz-in. stall torque which varies directly with the control winding voltage. This new motor is $1\frac{1}{4}$ in. dia by $1\frac{3}{8}$ in. long and weighs 6.1 ounces. It is especially adapted to servo systems used in military and aircraft computers, automatic pilots, and fire control computers, as well as various laboratory equipment.

Miniature Adjustable-Speed Drive

Metron Instrument Co., 432 Lincoln St., Denver 9, Col.

New miniature variable-ratio speed changer weighs less than six oz, delivers 70 oz-in. torque, and 0.025 horsepower. It can be used on business machines, recorders, controllers, computers, and similar devices. Speed range is 36 to 1, with a ratio of input to output speeds that is

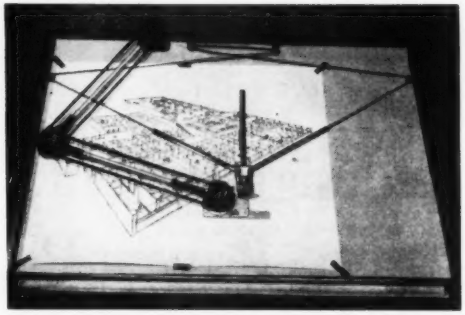


adjustable between 1 to 6 increase and 6 to 1 decrease. A dial and pointer indicate ratio setting and the adjusting knob is equipped with friction drag to prevent ratio wander. Operating speeds up to 20,000 rpm are practical, with maximum output torque obtainable at zero speed. Internal construction employs rollers and contacting disks on input and output shafts. Speed is adjusted by changing the radius at which the rollers make contact. "Lock-up" devices are provided to increase contact pressure automatically when the load torque is increased.

Drafting Instrument

Charles Bruning Co., Inc., 4754 Montrose Ave., Chicago 41, Ill.

Called the "Perspect-O-Matic," the new instrument attaches to any drafting machine and guides the draftsman's pencil toward the established vanishing points from



any position on the drawing board. A small pulley is clamped over each of the chosen vanishing points, and the swinging left and right scale arms are held in strict alignment with these points by a piano wire spring. To prevent scales from shifting under pressure of the pencil, a thumb operated brake is provided. By permanent locking, the instrument can be used for isometric drawings. The scales are marked with constantly diminishing graduations as draftsman moves toward the vanishing point to keep dimensions in proportion. One edge of each scale is marked fractionally and the other decimally. Either edge may be used uppermost. When a drafting machine is not available the "Perspect-O-Matic may also be attached to any standard parallel ruling straight edges.

Hex Socket Pipe Plugs

Allen Mfg. Co., Hartford 1, Conn.

Pipe plugs are entirely pressure formed and threaded. This process gives a strong head and smooth, burnished threads, to provide a tight seal. Plugs are made for use in installations where a tight seal is essential, and any sort of sealing compound would be unsafe or inadvisable, particularly where extreme pressures are involved. Such applications include refrigeration; marine, automotive, and aircraft fuel and oil line fittings; and drain and filler plugs. Threads are in accordance with Army-Navy Aeronautical specifications AN-P-363. A size range of 1/16 to $1\frac{1}{4}$ in. is available.

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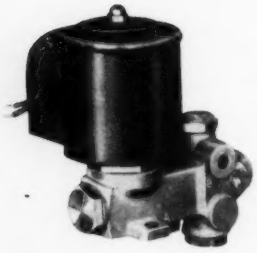


Packless Solenoid Valves

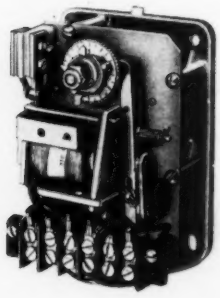
Automatic Switch Co., Orange, N. J.

Valves are designed for handling steam up to 250 psi at 450 F. They are operated directly by a solenoid through a power-multiplying internal lever. Solenoids are protected with brazed core tube joints. Coils are of either a high temperature glass insulated winding or silicon winding built for continuous duty service. Valves are supplied standard with cast bronze bodies, although cast iron bodies are available. Valve seats, disks and springs are stainless steel, and are operated by a stainless steel lever. Valves are available with standard, explosion proof, or water-tight housings. Pipe sizes are $\frac{1}{8}$, $\frac{1}{4}$, $\frac{3}{8}$ and $\frac{1}{2}$ in.; port sizes are $\frac{3}{16}$, $\frac{1}{4}$, $\frac{5}{16}$ and $\frac{3}{8}$ inches.

Delay Relay

Eagle Signal Corp., Moline, Ill.

Relay, known as Timoflex, provides timed closing or opening of electrical circuits. Equipment is available in three basic models. One model starts timing when the pilot switch is closed, when the pilot switch opens, and when a pushbutton is closed momentarily. Operation is provided by a slow speed synchronous motor with a separate reset coil to release the timing mechanism. The timer is available with standard timing scales of 55 sec, $5\frac{1}{2}$ min, $27\frac{1}{2}$ min, or 55 min. Relay measures 3 x $4\frac{1}{2}$ in., and is provided with a removable bakelite cover.



Jet Pump Motors

Brown-Brockmeyer Co., Dayton, Ohio.

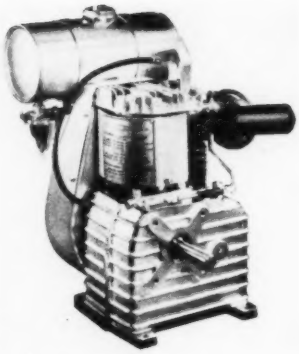
B-Line motors are available in ratings from 1/6 through 1 hp, with 40 C rise, for continuous duty. They are the flat face type suitable for either vertical or horizontal mountings, with mounting dimensions identical for all ratings. Standard shaft extension or threaded shaft for direct connection

to the pump impeller (see illustration) can be furnished. Motors are available from 1/6 through 1 hp for single phase capacitor start induction run type, 115 or 115/230 volts. Single phase motors have an automatic thermal overload protector. Two or three phase squirrel cage induction types, 220 or 220/440 v, as well as compound wound d-c motors of 115 or 230 v are available from $\frac{1}{2}$ to 1 horsepower. Operation is at 3,450 rpm at 60 cycles and 2,850 rpm at 50 cycles.

Small Gasoline Engine

Uhelhoer Bros., Inc., 848 Kensington Ave., Buffalo 15, N. Y.

Ultimotor Model 12 is a 4-cycle engine developing $1\frac{1}{2}$ hp at 2,300 rpm and 2 hp at 3,000 revolutions per minute. It weighs 38 lb and stands

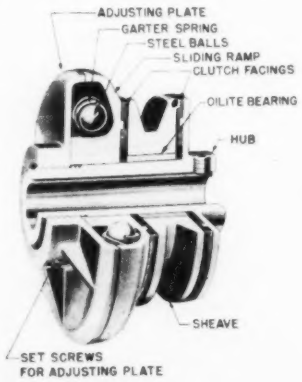


16 in. in height. Assembly employs aluminum in the cylinder head, connecting rod, crankcase and piston. It has a 2 in. bore, $2\frac{1}{4}$ in. stroke, and 7.07 cu in. piston displacement. Compression ratio is 6.13 to 1. Ignition is provided by a high-tension flywheel-type magneto with a dust shield. Engine has a centrifugal-type governor which is adjustable to full power range, and which can be cable controlled.

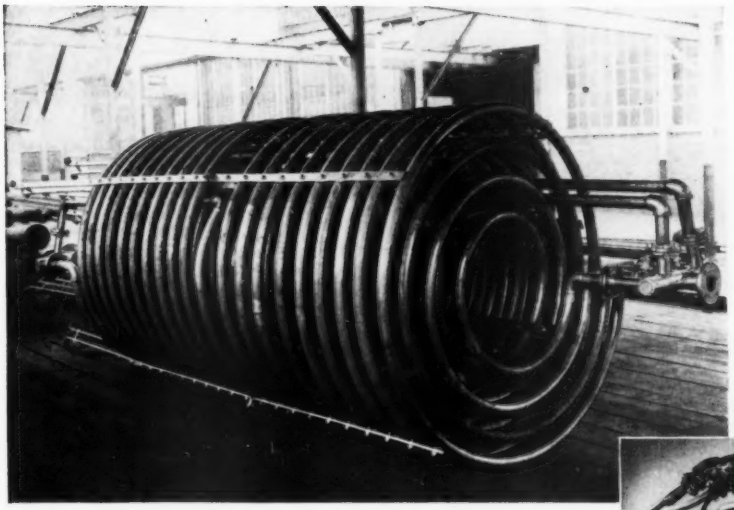
Lightweight Clutch

The Salsbury Corp., 1161 E. Florence Ave., Los Angeles 1, Calif.

Salsbury Gripmaster automatic clutches are available for all standard makes of engines with shaft sizes of $\frac{1}{2}$ to $1\frac{1}{2}$ in. and up to 10 horsepower. In operation of the clutch, steel balls inclosed in a garter spring, which controls engaging speed, act as the weight assembly. As engine speed is increased above idling range, centrifugal force moves the weight assembly out



Why CRANE-fabricated pipe coils are the finest available



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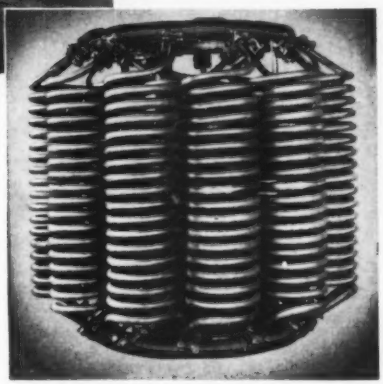

17 pipe coils in one—*completely fabricated by Crane.*

The explanation is simple enough. Crane is the world's foremost designer and fabricator of industrial piping equipment. Five Crane Shops, strategically located throughout the country, offer you the special facilities needed for fabricating pipe coils to precise requirements.

No pipe coil design is ever too large or small . . . or too complex . . . for Crane Shops to handle. Skilled manpower and superior equipment combine to assure efficient fabrication of practically every size, shape and type of tubular material.

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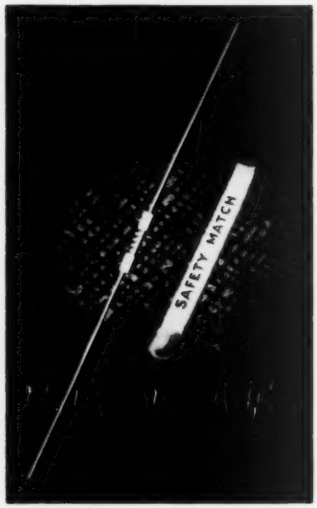
FOR EVERY PIPING SYSTEM

radially in the sliding ramp. This causes the driving member (sheave or sprocket) to be gripped between clutch facings. This series of clutches quickly develops its maximum torque. May be used with light agricultural equipment, power lawn mowers, power saws, motor bikes, small generators and similar units.



Small Resistors

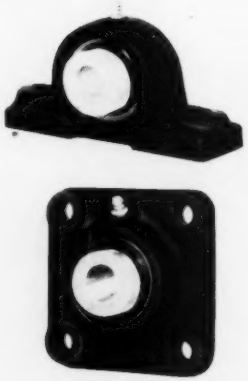
Wilkor Products, Inc., 3845 *W.* 150*th St., Cleveland* 11, *Ohio.*

Small carbofilm resistors, for use in the manufacturing of miniature electronic units. Available in sizes from $\frac{1}{4}$ to 1 watt, in values from 20 ohms to 5 megohms and with tolerances of $\frac{1}{2}$ to 1 percent. Smallest resistor in line measures 1/16 in. dia over caps, $\frac{3}{8}$ in. all-over length, with $1\frac{1}{2}$ in. tinned copper leads. Insulation optional.

Low Speed Ball Bearing Units

Roberts Machine Works, Minnesota Bearing Co., 1619 *Hennepin Ave., Minneapolis* 3, *Minn.*

New series includes both pillow block and flange units in sizes for shafts from $\frac{1}{2}$ to $1\frac{1}{2}$ in. dia. Units are to be run with medium loads and shaft speeds up to 1,000 rpm, and are recommended for use with farm machinery and conveyor equipment. One piece housings are made of cast iron, and are equipped with standard grease

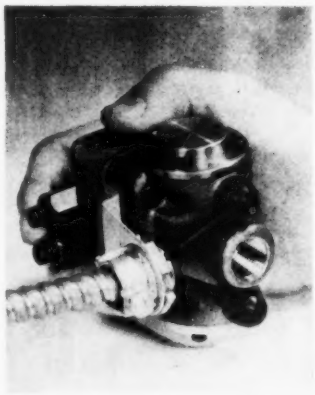


fittings. Allowance is made for normal misalignment of the shaft. Bearings move in alloy steel races with the inner race locked on the shaft by two set screws spaced 90 deg. apart.

Air Control Valve

The Bellows Co., 222 W. Market St., Akron, Ohio

Solenoid-actuated air control valve is operated by the air it controls. Assembly consists of a cast bronze body with a single air inlet, electrical terminals and a cylinder in which floats a light weight piston. This piston engages and shifts a 4-way air valve. The caps inclosing each end of the cylinder hold 8 v solenoids which release the full pressure of the air supply line to drive the piston. The solenoid plungers have only a 1/32 in. movement. Valves are adapted to direct connection or remote control of any standard air cylinder and will operate with 5-150

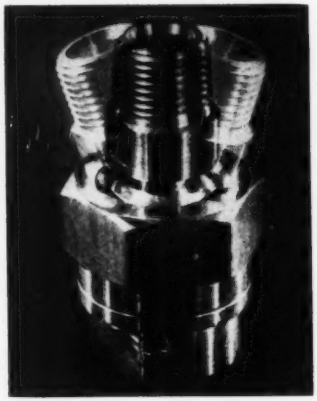


lb air line pressure. Available in $\frac{1}{4}$ and $\frac{3}{8}$ in. port sizes, valves come complete with a special transformer to reduce normal line voltage to the required 8 volts.

Ball Joint Coupling

Kelite Products, Inc., Box 2917, *Terminal Annex, Los Angeles* 54, *Calif.*

The Kelite swivel ball joint will turn 20 deg in any direction with no restriction of flow. It absorbs vibration and movement in all installations where pipe cannot be rigidly supported. Leakage is eliminated by an "O" ring which gives a positive seal at any pressure. The greater the pressure, the tighter the seal, yet free movement is maintained at pressures



far beyond normal requirements. The standard $\frac{3}{8}$ in. joint is good for pressures from $\frac{1}{4}$ oz to 150 lb psi, and for temperatures up to 350 F. Models for any size pipe and for higher pressures and temperatures are available.

Chemical Polish

Allied Research Products Inc., 4004 E. Monument St., Baltimore 5, *Md.*

Known as Iridite Metcote, chromate type chemical polish is for use on copper, brass and bronze surfaces. Applicable to sheet, rod, castings or forgings, polish produces a corrosion resistant surface and a paint base in addition to its polishing action. Coating is applied by a non-electrolytic dip, and work being processed does not become etched, even after long immersion periods.

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THE COMMERCIAL GRADE SERIES B

BALL BUSHING

Sliding linear motions are nearly always troublesome. Thousands of progressive engineers have solved this problem by application of the Precision Series A Ball Bushing.

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NOW AVAILABLE for ¼", ½", ¾" and 1" shaft diameters. Additional sizes to follow. Write for new literature covering both the Series A and Series B Ball Bushings and the name of our representative in your city. No obligation.

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Silicone News

DC SILICONES

DC Silicone (Life-time) Lubrication Pays Dividends

The more progressive manufacturers of electrical equipment have found that DC Silicone (life-time) lubrication gives their customers long term, trouble-free service. That's true in motors ranging from industrial units to the "flea-power" synchronous motors used in the kilowatt demand meters and time switches made for electric utility companies by Sangamo. These devices must give several years of continuous and absolutely accurate service whether they're installed in the North where temperatures drop to −40°F. or in the South where internal temperatures reach 180°F.

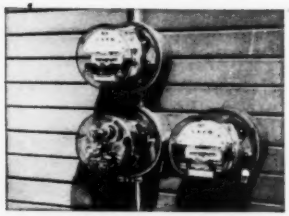

PHOTO COURTESY SANGAMO ELECTRIC COMPANY

DC 33 Silicone Grease retains its consistency to permit timing motors in demand meters and time switches to operate at constant speed in spite of varying climatic conditions

Sangamo engineers specified DC 33 Silicone Grease for the bronze sleeve bearings of these small synchronous motors after extensive comparative testing. Their tests proved that DC 33 was superior to any other lubricant for this application because it is practically non-volatile, heat-stable, and because it has low torque at low temperatures. Final proof is the fact that thousands of these little motors have given faultless service ever since Sangamo started to use DC 33 Silicone Grease over 3 years ago.

In oven and toaster timers, parking meters, wind velocity indicators and in the permanently sealed bearings of industrial motors, Dow Corning Silicone Oils and Greases have made permanent lubrication a practical reality. You can obtain more information about Dow Corning Silicone Greases from our nearest branch office or by writing for data sheet No. D5G6.

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FIRST IN SILICONES

NEW BOOKS

Photoelectricity And Its Application

V. K. ZWORYKIN, *Director of Electronic Research, Vice President and Technical Consultant, Radio Corporation of America;* E. G. RAMBERG, *Research Physicist, R. C. A. Laboratories Division, Princeton, N. J. Third Edition, revised.* 478 *pages,* 6 x 9 *in. Published by John Wiley & Sons, Inc., New York, N. Y.* $7.50.

This is the Third Edition of a book that endeavors to familiarize the reader with the properties, preparation and use of photoelectric devices. The emphasis is on the practical aspect of the subject. The book is divided into two general sections. The first eleven chapters deal with the principles of preparation of photo sensitive devices. The remaining chapters cover their application.

Because progress in photoelectric devices has been so rapid, considerable revision has been required to cover recent findings, such as the antimony-cesium phototubes, the image tube, and the high gain secondary emission multiplier. Photoelectric measuring devices are covered in one chapter which highlights the application to motion picture sound, facsimile, television, and infrared detection techniques.

There can be no doubt that this book provides a broad background for the engineer who wants to familiarize himself with these tools and the concepts underlying them.

Industrial Applications Of Infrared

JAMES DOYLE HALL, *Advisory Engineer, Westinghouse Electric Corp.,* 201 *pages,* 6 x 9 *in. Published by McGraw-Hill Book Co., Inc.,* 330 *West* 42*nd St., New York, N. Y.* $3.50.

Since November, 1938 when publicity first was given to the Ford Motor Company's process for drying finishes on car bodies with infrared tunnels, there has been great interest in infrared radiation as a source of heat. This book is intended as a non-technical source of reference on the applications and use of infrared.

Heat formulas and theoretical calculations are avoided. There is presented instead a lot of data drawn from tests and experience. Emphasis is placed on the practical rather than the

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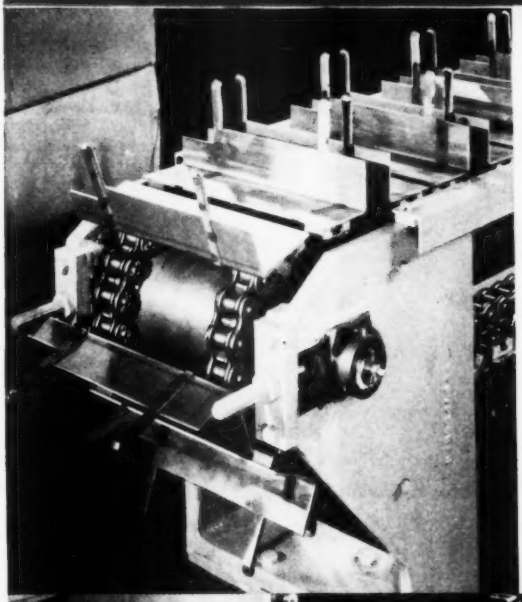
DIAMOND ROLLER CHAINS



• High speed automatic packaging and conveying machinery today pays its way through steady high output dependability. Here accuracy of timing and coordination of the various motions are all important.

Precision-made Diamond Roller Chains have established long time performance records on the finest machinery — for transfer of power from motor to main shaft, from shaft to shaft, and with various types of attachment links for packaging and conveying operations.

If you use or build automatic machinery, you find it pays to insist on DIAMOND Roller Chains. Practical suggestions from our specialized engineering staff are yours for the asking. Catalog 649 mailed on request.

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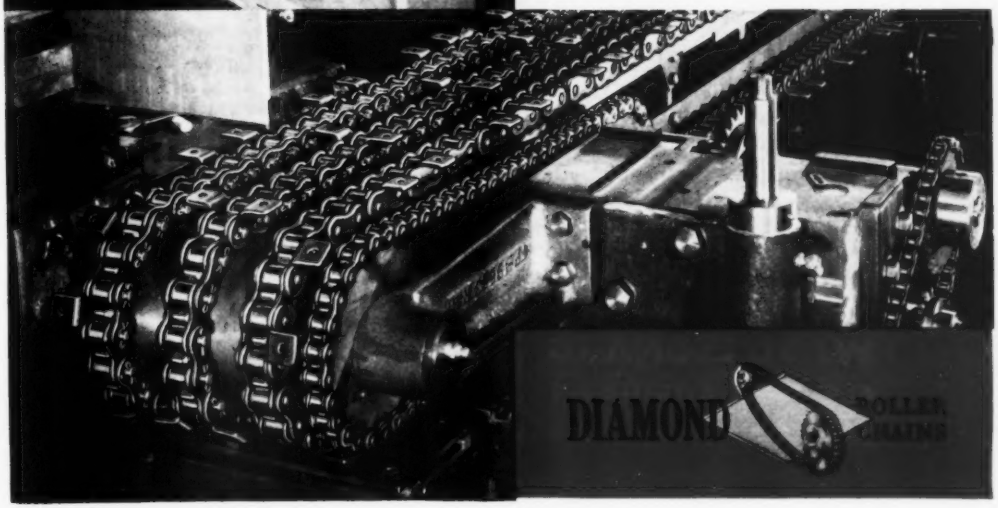
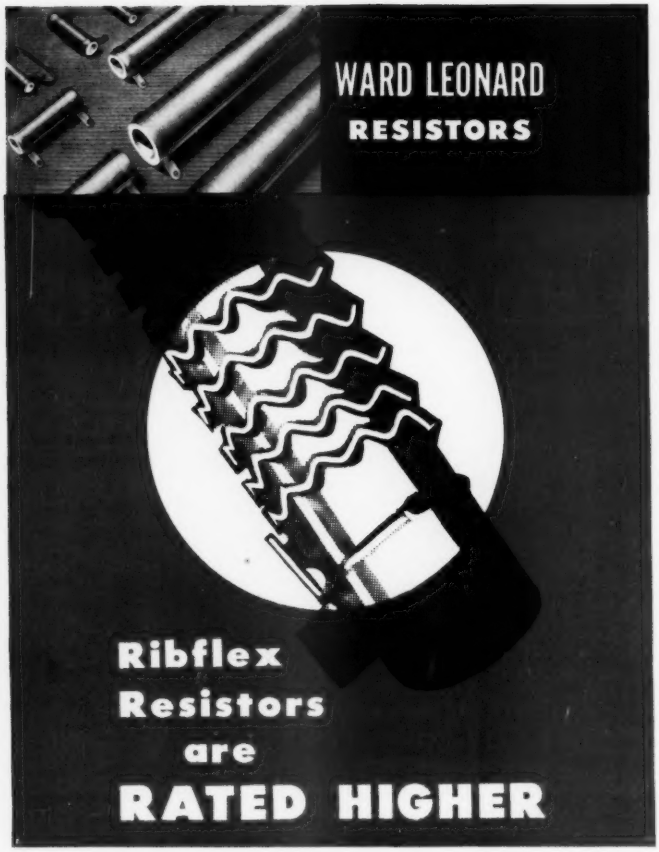
Both illustrations show use of Diamond Roller Chains on packaging machinery made by the well-known firm R. A. Jones & Co., Covington, Ky.





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Whether for continuous or intermittent duty, the high watt rating and low ohmic values make them first choice for a wide variety of heavy duty applications.

Write for Resistor Catalog. Ward Leonard Electric Co., 63 South Street, Mount Vernon, N. Y. Offices in principal cities of U. S. and Canada.

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theoretical. Simple test procedures are outlined. Typical chapters cover—Radiant Heat Equipment; Design of Infrared Installation; Application Problems and Industrial Applications.

The variety of infrared installations photographically recorded and described should be of assistance not only in the solution of specific problems but also in suggesting additional uses of radiant heat to the reader.

Meet the Plastics

CLARK N. ROBINSON, *172 pages, 6¼ x 9½ in. Published by The Macmillan Co., 60 Fifth Ave., New York, N. Y.* $3.75.

This book has been written to make knowledge about plastics available to the non-specialist. The author explains in simple terms the basic chemistry of plastics, the ingredients and special characteristics of each of the various kinds of plastics, the forms in which each is available, and the use of processing methods for each. He then describes the plastics industry and its branches.

At the end of the volume, there are useful reference lists of plastics manufacturers and sources of supply, materials and trade names, schools giving technical training in plastics, and sources of information about plastics.

Developing and Selling New Products

GUSTAV E. LARSON, *U. S. Department of Commerce. 75 pages, 6 x 9 in. For sale by Superintendent of Documents, U. S. Government Printing Office, Washington 25, D.C. 25 cents.*

Manufacturers looking for new products to round out their lines and keep their employees and machinery working full time will be helped in their search by a new U. S. Department of Commerce publication, "Developing and Selling New Products."

Based on first-hand information supplied by a hundred business firms that have successfully developed and sold many new products, the booklet describes methods of locating new product ideas; selection of a product and its preparation for the market, including designing, naming and packaging.

The publication provides a checklist of major sources of new product ideas, suggestions for undertaking surveys, plans for organizing a company for the new product task, a list of design essentials, examples of how to test a product and a guide for naming a new product.

An interesting tabulation shows how twenty-five manufacturers located ideas

for profitable new products. Among the products and sources of ideas are a garage hoist, proposed by an automobile mechanic; a steam producing unit listed in an advertised sale of manufacturing rights; and machines for use in textile mills, developed by a machine tool manufacturer.

The term "new product," as used in the Commerce Department publication, covers; (1) products entirely new and not previously manufactured; (2) products new to an industry; and (3) redesigned products.

Bibliography On X-Ray Stress Analysis

HERBERT R. ISENBURGER. *17 pages, 8½ x 11 in., unbound. (Reproduction of typing). Published by St. John X-Ray Laboratory, Califon, New Jersey.* $3.

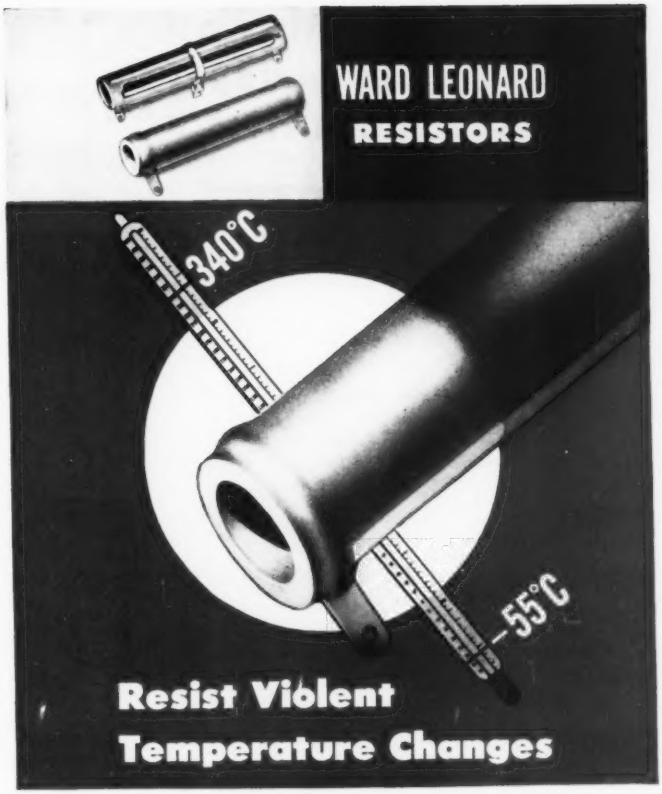
This 1949 edition of a Bibliography On X-Ray Stress Analysis is intended to bring the reader every possible reference on the subject. To facilitate its use, a subject index has been added. 240 references are given. The subject index covers four pages. A brief discussion of the X-ray method is included in the bibliography.

Must We Hide?

R. E. LAPP. *First Edition. 182 pages, 8½ x 5½ in. Published by Addison-Wesley Press, Inc., Cambridge 42, Massachusetts.* $3.

This is a scientist's answer to the sensationally pessimistic outlook on atom warfare as expressed in David Bradley's recent book, "No Place To Hide." Dr. Lapp conceived this book as an attempt to educate the American public on the facts—not imaginings—of atomic warfare.

MUST WE HIDE? endeavors neither to depreciate or exaggerate the effects of the atomic bomb. The author considers the nature of atomic bomb damage on material and humans. Blast, heat and radiation effects are described. He then presents the results of the Japanese bombings and translates these effects to American cities. In maps and discussion he shows how our air attacks on Japan were executed, the effort required and the destruction resulting. The imposition of similar damage on American cities of appropriate size is shown in detail on a map. Until one studies this map, it is almost impossible to appreciate the wide spread damage done by our high explosive-fire bomb attacks. Not many Americans realize that fire bomb attack on Tokyo, March 9, 1945 wiped out 15 square miles and close to 100,-



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Switch the temperature back and forth from 340 to −55°C, over and over, and still you won't affect the stability of Ward Leonard Vitrohm Resistors.

Reason is: Ward Leonard, making all components*, can control thermal characteristics so as to survive the greatest temperature variations.

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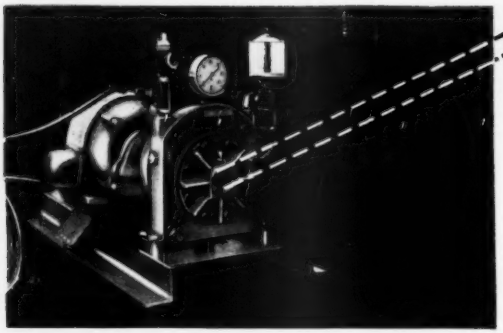
GAST rotary AIR COMPRESSOR

PURPOSE Assure an even flow of dry bulk material through bin hoppers of portable and stationary concrete plants.

APPLICATION Aeration of material around hopper opening with low pressure of 10 to 15 p.s.i., volume of 8½ c.f.m. A Gast 1065-P17 Rotary Air Compressor supplies dry, non-pulsating air at low cost with ½ to ¾ h.p. motor or V-belt from gas engine.

RESULTS Excellent. This manufacturer has used Gast Units as original equipment for many years.



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Whether your problem is similar—or far different from this—you too may find that "Air may be your Answer". As original equipment for literally hundreds of applications, Gast Rotary Air Compressors, Air Motors and Vacuum Pumps help manufacturers to improve their *products*—and *save money!*

For example, consider the Air Compressors used on this application. They deliver *positive pressure without pulsation* . . . and *without a bulky air tank* . . . at lower initial cost. And they offer many other advantages—resulting from the *utter simplicity* of their sliding-vane Rotary Design.

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000 inhabitants; a destruction that the atom bomb by no means equaled.

By analysis of the construction of our cities, and the known effects of the atom bomb, Dr. Lapp makes the potential damage an understandable, less frightening although terrible, thing.

The problem of atomic defense is the heart of the book. Dr. Lapp offers an appreciation of the problem of the enemy's delivering an atomic attack, planning for disaster, and the necessity for dispersion.

Those who are interested in the realities of atomic warfare will find this book to be a refreshing change from the Sunday supplement atmosphere of most other books and articles on the subject.

1949 Modern Plastics Encyclopedia

Published by Plastics Catalogue Corp., 122 East 42nd St., New York, N. Y. 1371 pages, 8¼ x 11½ in. $5.00.

The latest edition of the Modern Plastics Encyclopedia contains, as usual, a complete source of reference material in every phase of plastics.

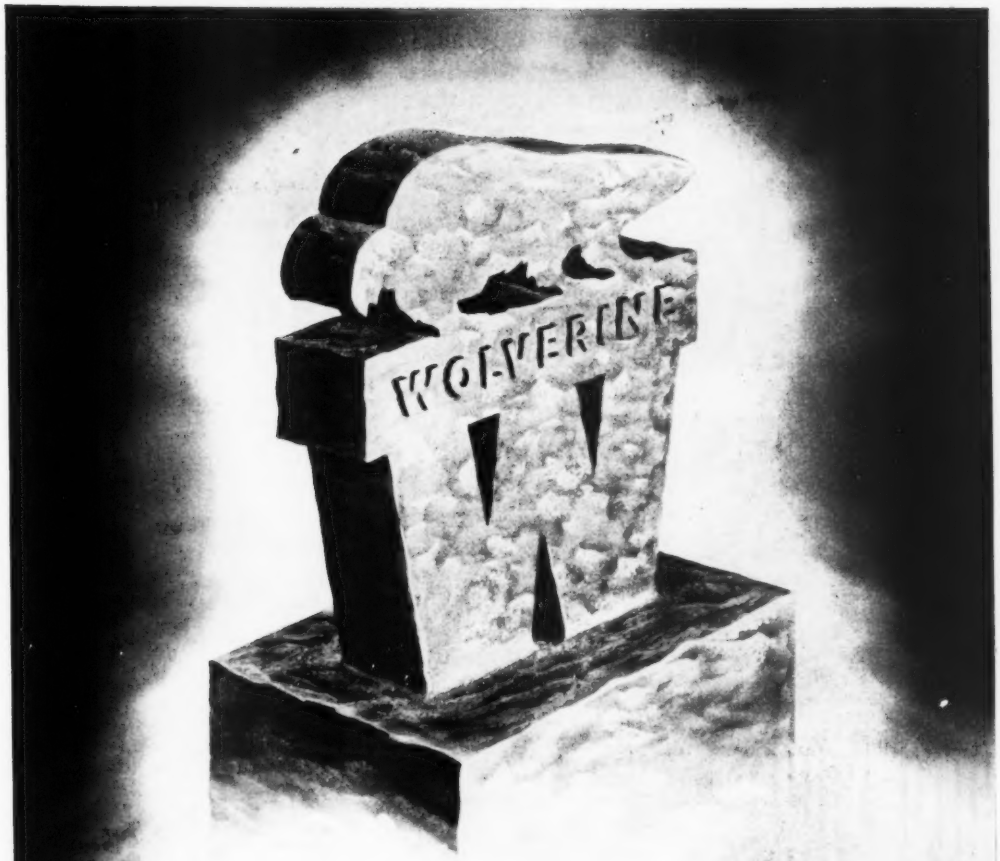
This year, a 200-page lead section entitled "Plastics in Use" has been added. This section emphasizes applications of plastic materials, and describes various plastic products under 27 different headings. The technical data section includes an important new article "Survey of the Properties of Plastics", which has been abridged from a report prepared by Battelle Memorial Institute for the Office of the Chief of Ordnance. This can be used in conjunction with the plastics properties charts.

Gas Turbines For Aircraft

F. W. GODSEY, JR., *manager, New Products Div., Westinghouse Electric Corp., and* LLOYD A. YOUNG, *Rand Corp. First edition. 344 pages, 6 x 9 in. Published by McGraw-Hill Book Co., Inc., 330 West 42nd St., New York 18, N. Y.* $4.50.

The gas-turbine idea is not new, but its practical realization as an aircraft turbojet or turboprop power plant has come within the last five years. This newness, coupled with the fact that many developments are still held under military security regulations, has made for a difficult task of presentation.

While the book is written specifically for the student and for engineers in the aviation industry, there is much basic material which will be helpful to those interested in the use of the



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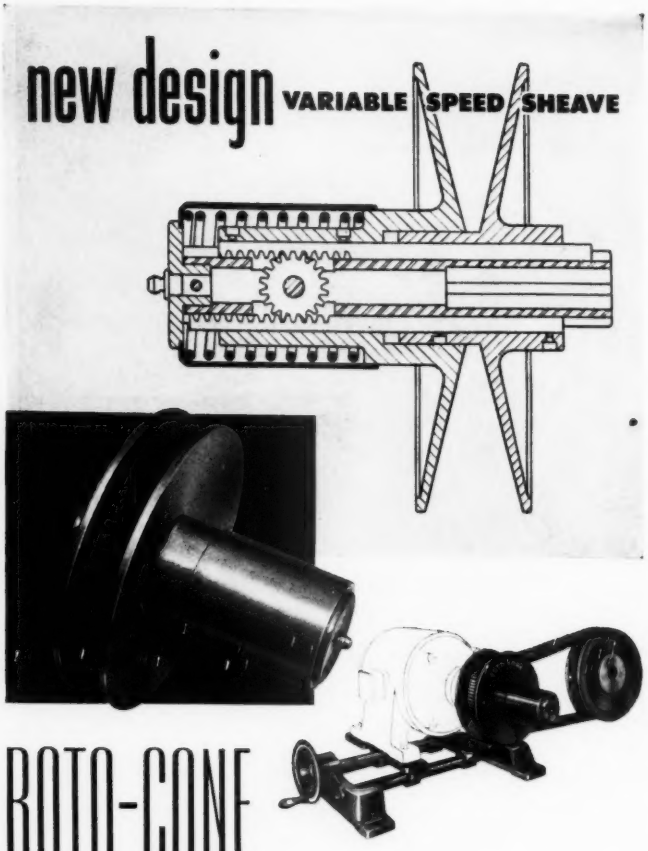

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Double rack and pinion provides equal movement of both sheave faces on the ROTO-CONE. That means a constant belt centerline and full power with a V-groove driven sheave. Belt life is lengthened . . . torque load, noise and vibration are eliminated. No shaft extension or countershaft required. The ROTO-CONE is ideally suited to vertical or horizontal mountings with sizes available to meet horsepower requirements from ⅛ to 7½.

ROTO-CONE drives include variable speed sheaves, V-groove driven sheaves, wide V-belts and adjustable motor bases . . . all engineered for lowest cost speed control. All sizes available from stock. Write or call today for details and the assistance of qualified engineers in selecting the ROTO-CONE drive to fit your equipment.

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gas turbine as a prime mover in stationary and marine applications.

The first three chapters are basic. They present background material that will be needed for a good understanding of the subject. Chapter 3, for example, gives a thorough review of gas flow, as it applise to gas turbines. The reader who is primarily interested in the characteristics of gas turbines and their components will find it possible to start reading at Chapter 4 without serious loss of continuity.

Subjects covered include gas turbine compressors, fuels and burners, turbines and their characteristics, the jet nozzle, gas-turbine cycles, some variants of simple gas-turbine cycles aircraft-gas-turbine accessories and controls, and a chapter on the present development status of gas turbines for aircraft.

The book concludes with a graphic presentation of data on air and fuels.

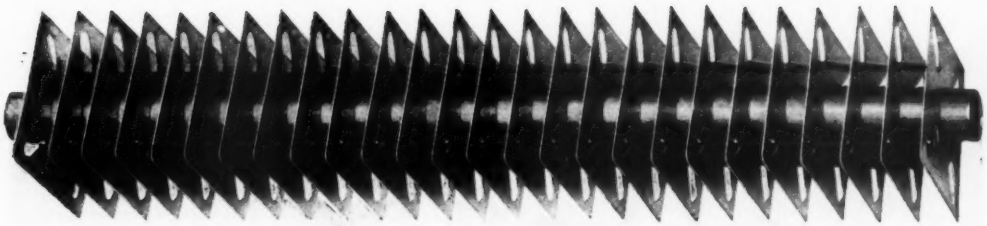
Plant Production Control

CHARLES A. KOEPKE, *Production Management Consultant. Second Edition. 557 pages, 6 x 9 in. Published by John Wiley & Sons, Inc., New York, N. Y. $5.50.*

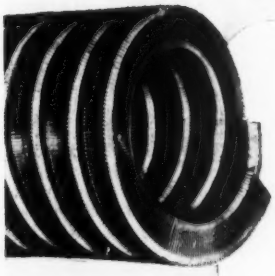
This is a revision of one of the first texts dealing with the specific, rather than the general, in the field of industrial engineering. Accurate and current data for all parts and materials is essential for good control. Therefore, the design engineering department becomes an important part of successful control schemes, as many firms learned during the war. The revision consists largely of additions and changes to incorporate current practices for controlling production.

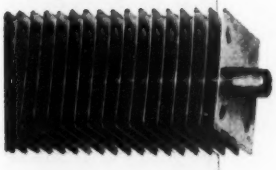
After a review background of modern industry, including the effect of such production factors as cutting tool materials, methods of measuring, better methods, new materials, plant design and layout, the author considers systems for production control and methods for installing such a system. An excellent outline of activities or steps in installing a system is given in pages 33-38.

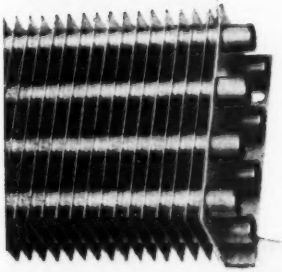
Under Organization For Production Control, the general duties of department heads are described. Chapter 5 discusses the importance of product design or specification in good production control. Materials and their classification for production control purposes, the effect of materials on production, the effect of production processes on overall economics, are covered. Economic purchasing quantities and methods of determining these figures are covered. Preferred numbers, problems of standardization in both



BUSH *Finned* TUBING







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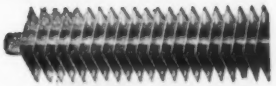

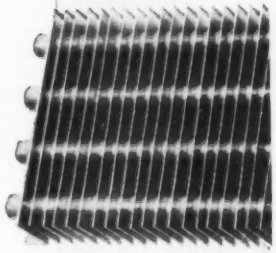

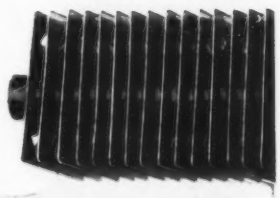

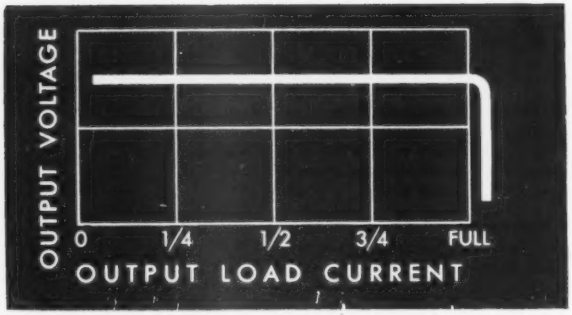

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parts and production machinery are analyzed. The chapter on alternative production methods, while not particularly comprehensive, does contain valuable suggestions. Machine replacement and methods of analyzing replacement problems are considered. There is considerable attention to details of production control systems, such as Gantt charts, scheduling, dispatching, inventory control, and similar topics. All in all, this book is a good introduction to the basic problems of production control.

Mathematics For Electricians

MARTIN H. KUEHN, *Principal, Technical High School, Buffalo. 372 pages, 5½ x 8 in. Published by McGraw-Hill Book Co., Inc., 330 West 43nd St., New York, N. Y. $2.80.*

This book aims to satisfy the need for a volume in which problems in practical electricity are combined with the principles of mathematics used in their solution. It should be of material aid to the non-electrical engineer who wishes to study the basic mathematics involved in electrical calculations. The reader will find numerous illustrative examples for which the solutions are given. Explanations are straightforward and complete to permit self-instruction.

This is the Third Edition of the book. All material has been brought completely up to date. The chapter on power has been rewritten to include the concept of work and horsepower. The alternating current section now includes problems dealing with balanced three-phase circuits. New problems have been added dealing with the conversion of coal and water pressure into electrical energy.

The book also separately explains each phase of mathematics before describing its application to the solutions of electrical problems. Thus, the reader gets a thorough refresher in subjects such as logarithms, trigonometry, quadratics and others.

Handbook of Patents

HARRY AUBREY TOULMIN, JR., *800 pages, 6¼ x 9½ in. Published by D. Van Nostrand Co., Inc., 250 Fourth Ave., New York, N. Y. $9.00.*

A frequent contributor to the pages of PRODUCT ENGINEERING, H. A. Toulmin, Jr., prominent patent attorney of Dayton, Ohio, has compiled in this volume a complete source book of reference information in the field of patents. The object of the book is to furnish the philosophy on which the patent law is grounded and an un-

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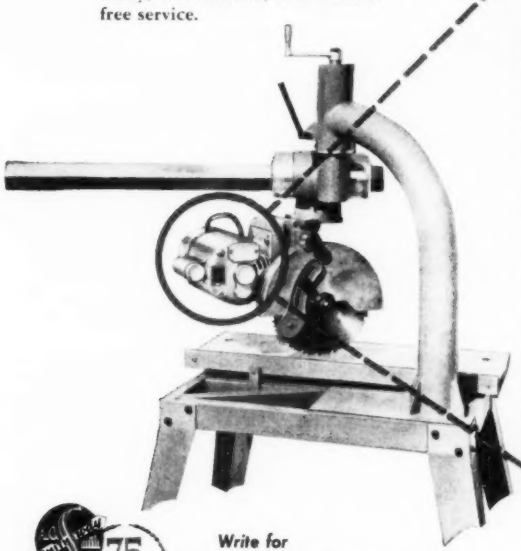

MOORADIAN PORTABLE RADIAL SAW, product of Mooradian Manufacturing Co., Los Angeles 11, does the work of six machines. It has a wide range of uses, including compound miters. The operator can "gang-up" long pieces to cut multiple parts. Belt drive permits choice of many speeds not obtainable with direct-drive saws.

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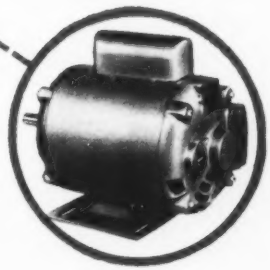

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derstanding of the relationship of the patent law to manufacturing, research, and engineering, on which our industrial prosperity is founded. Each chapter is a guide to the steps that must be taken, from investigating the novelty of an idea through preparing a patent application, prosecuting it to an issued patent, and thereafter protecting it by litigation in the courts. Also, the international situation is discussed, with chapters on foreign patents and the treaties and conventions dealing with patents to which the United States is a party.

The manuscript for this volume served as a basis for a two-part article entitled "Patents and the Engineer", which appeared in June and July 1948 PRODUCT ENGINEERING.

Welding Metallurgy

O. H. HENRY, *Professor of Metallurgical Engineering, Polytechnic Institute of Brooklyn, and* G. E. CLAUSSEN, *formerly Adjunct Professor of Metallurgy, Polytechnic Institute of Brooklyn: revised by* G. E. LINNERT, *Senior Research Engineer, Armco Steel Corp. Second edition.* 505 *pages,* $5\frac{1}{2}$ x $7\frac{3}{4}$ *in. Published by American Welding Society, 33 West 39th St., New York, N. Y.* $2.50.

The present revision incorporates extensive rearrangement of the material in Henry and Claussen's original publication. Their first edition contained two volumes that were prepared from material presented during fundamental and advanced lecture courses on metallurgy and metallography at Polytechnic Institute of Brooklyn under the joint auspices of the Institute and the New York Section of the American Welding Society.

As in the original 1940 edition, the theme of this single volume is to familiarize members of the welding industries, including fabricators and designers, with the composition and structure of the steel, to show how the steel is affected by the varied conditions of heat and stress in welding, to explain the mysteries of heat treatment, and to point out the way in which metallurgy can be used to control the welding process.

Much of the recent progress in welding can be attributed to the increasing knowledge of the metallurgy of welding. It would be sheer folly to weld alloys like the high-strength heat-resisting steels or the age-hardening aluminum alloys if their metallurgical characteristics were not known. Materials such as these can be joined only when, as Henry and Claussen have previously annotated, "we relate the temperature changes during welding to

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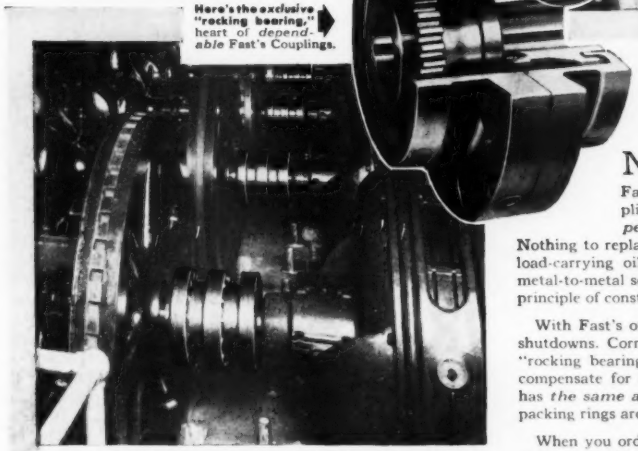
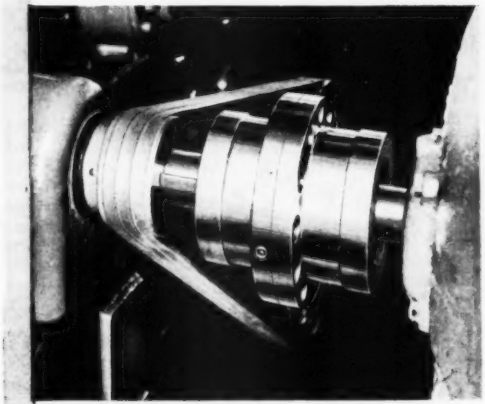
IN OIL FIELDS Fast's are in service to compensate for shaft misalignment, in all kinds of weather, subject to moisture, dirt and grit . . . yet they transmit power without costly coupling shutdowns!



Here's the exclusive "rocking bearing," heart of *dependable* Fast's Couplings.

CHEMICAL PROCESSING plants use Fast's Couplings because *exclusive* metal-to-metal seal keeps out impurities . . . eliminates lost time due to coupling failure! These Couplings have been in service since 1922!



MANUFACTURING processes of all kinds throughout industry demand *dependable* Fast's Couplings that *do not break down* under severe conditions!

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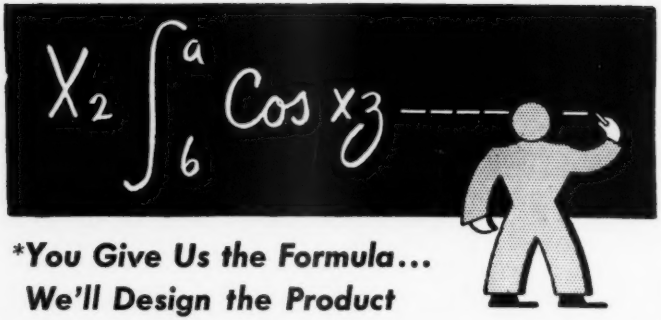

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changes in the structure and properties of the joint."

The information that has been garnered on welding metals during the last eight years has been sifted and that which rightfully belongs in a text on this subject has been included as new material. As before, steels or ferrous alloys are the center of most discussions. Although relatively few references are made to other commonly used metals, much of the information is very general in character and can be applied to many metals. The Fahrenheit temperature scale has been given preference throughout this new edition because this scale is used to a greater extent by far in the United States than the Centigrade scale. An index has been added.

Principles of Electricity And Electromagnetism

G. P. HARNWELL. *Professor of Physics, University of Pennsylvania. Second Edition.* 655 *pages*, 9 x 6 *in. Published by McGraw-Hill Book Co., Inc., 330 West 42nd St., New York* 18, *N. Y.* $6.

A fundamental basis of the physical phenomena in experimental and theoretical electricity are covered by this text. The emphasis is on the experimental rather than the theoretical point of view. There is considerable coverage of electronics and gas discharges. It is definitely a text for advanced students, and it incorporates many important developments in electricity that have occurred in recent years.

A section on ultra-high frequency techniques has been added. The field of radar is not covered, but the basic techniques involved are described. There are discussions of wave guides, resonant cavities, and problems showing the application of electricity to industrial uses and economic research.

Chapters cover Electrostatics, Electrostatic Energy and Dielectrics, Direct-Current Circuits, Nonohmic Circuits, Chemical, Thermal and Photoelectric Effects, Thermionic Vacuum, Electrical Conduction in Gases, Changing Effects, Thermionic Vacuum Tubes, Electrical Conduction in Gases, Changing Electric Currents and Electromagnetic Reactions, the Magnetic Properties of Matter, Electromagnetic Machinery, Simple Circuits, Coupled Circuits, Vacuum Tube Circuits, and Radiation.

There is an excellent Mathematical Appendix which covers Taylor's Theorem, Fourier Analysis, Elementary Differential Equations, Vector Theories Necessary for the Description of Elementary Electric and Magnetic Phenomena, and Units and Standards.

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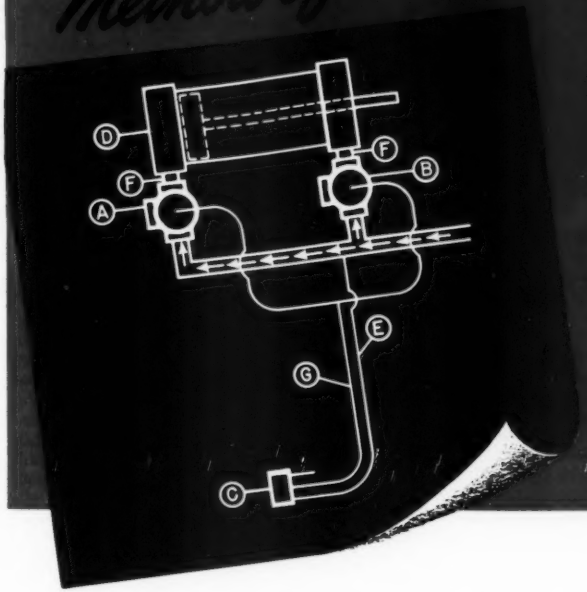

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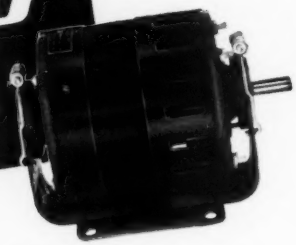

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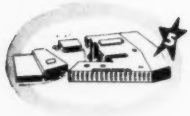

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OUR READERS SAY

Who and Where Is F.M.?

To the Editor:

Congratulations on your editorial in the April issue. I look forward to the feature, "How hundreds of companies are doing it," mentioned therein as forthcoming.

Can you please give me the name and address of the author of the "Heaven Might Help" letter in the April issue, at pages 178-9? Thank you. —JOHN F. SCHMIDT
Joy Mfg. Co.

Ed.—It happens that the author of the "Heaven Might Help" letter signed it F. M., without revealing his full name. He also failed to give his full address—just Edinburgh, Scotland. As might be expected, we received more requests for further information on this letter than any other in the April issue—thus putting us on the spot. If this reticent Scot will only see this and send us his name and address we will gladly inform his would-be correspondents.

That Easy Porcelain Finish

To the Editor:

We would greatly appreciate any additional information with regard to the "porcelain-like finish" mentioned in the May issue of PRODUCT ENGINEERING on page five.
—LEWIS L. SALTON
Salton Mfg. Co., Inc.

Ed.—This is the finish that requires only 420 F to bond to glass, ceramics, and metals. It gives a porcelain-like finish that is moisture and alkali-proof. For complete information write to United Lacquer Manufacturing Company, Linden, N. J.

Our Mistake

To the Editor:

In the March 1949 issue of PRODUCT ENGINEERING, page 153, in a description of a jet engine starter developed by AiResearch Manufacturing Company, there appears the statement that this starter has the interesting feature

Buyers everywhere want products that are easier to lift and move. They want products made from Dow

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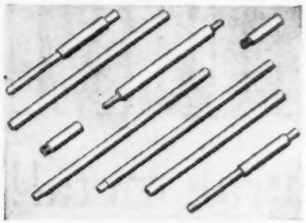

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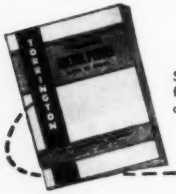

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4

of using "a 'radial inward flow' turbine, the first of its type ever operated in this country." It is assumed that the Francis type hydraulic turbine has been overlooked, and that the statement applies only to air or gas turbines.

Actually there is a fairly extensive background of experience in this country with radial inward flow air and gas turbines. A good deal of work done in this field has not been published, but the following references should quickly dispel any notion that the turbine described in the article is the first of its kind to be operated in this country:

J. S. Swearingen, Turbo-Expanders
Chemical Engineering Progress, Feb., 1947

I. S. Haverstick and A. M. G. Moody
High-Temperature Gas-Turbine Power Plants
Mechanical Engineering, April, 1945

A. W. McClure, The Elliott Turbo-Expander
Elliott Company Powerflax, Summer, 1948

Developments of this type date back at least fifteen years. In the United States several companies have been active in this field. Speaking only for the Elliott Company, it can be stated that not only are radial inward flow air and gas turbines in commercial service, but others are in the process of installation, and the company is actively interested in further developments in this field.

—ARTHUR W. MCCLURE
Elliott Co.

Ed.—We hate to make a mistake as badly as anyone else, and keep a constant check to see that our material is accurate. However, when we do slip up, as we did in this case, we are glad to have a reader with newer or more accurate information set us straight.

Some Like It Dry

To the Editor:

We note on page three of the May issue of PRODUCT ENGINEERING a paragraph dealing with a product called Neolube, a fast drying graphite solution.

We are wondering if you would be so kind as to furnish us with the name and address of the manufacturer of this product. —R. L. TOMPKINS
Clark Equipment Co.

Ed.—Neolube is a suspension of colloidal graphite in an alcohol. It's applied like paint and dries rapidly to a bright dry-lubricating film which does not blow or rub off. It produces a thin, smooth surface which can be used dry

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Flexible ALL METAL
COUPLINGS
FOR POWER TRANSMISSION
REQUIRE NO MAINTENANCE

Patented Flexible Disc Rings of special steel transmit the power and provide for misalignment and end float.

Thomas Couplings have a wide range of speeds, horsepower and shaft sizes:
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1 to 30,000 RPM

Specialists on Couplings for more than 30 years

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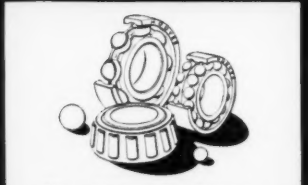
In bearings engineers judge quality by quietness. They know that the quietest running bearing makes the best showing in the battle against friction . . . and has the longest life. Hoover Ball Bearings with honed raceways . . . an exclusive Hoover feature . . . are the world's quietest ball bearings. This fact has been proved by sound testing on a special radio device. In comparison with four other leading makes, Hoover won hands down! The secret of Hoover leadership in quietness is the Hoover honed raceway. Mechanically honed on special machines, Hoover makes available, at reasonable cost, a ball bearing perfection previously found only in hand-honed laboratory samples. Write, on your letterhead, for a copy of the Hoover Engineering Manual.



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HOOVER
AMERICA'S ONLY BALL BEARING
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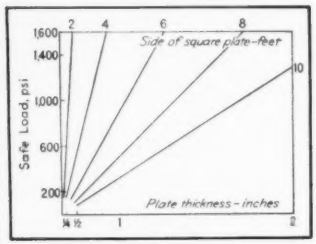
or with oil for heavier lubrication. For further details, write to Huron Industries, Box 557, Port Huron, Michigan.

Here's Another Way

To the Editor:

Mr. Tyler Hicks in April PRODUCT ENGINEERING, page 161, shows a family of hyperbolic curves of higher degree to solve the formula $p = 32460\ t^2/d^2$ for strength of square plates. This seems to the writer the hard way. If p and t are the coordinates a family of parabolas will be produced. If, however, p and t^2 are plotted as coordinates, the scale equation being $y = p/200$ and $x = 2.5t^2$, the family for "a" will be radial straight lines passing through the origin, easily and quickly drawn and probably more accurate. From the foregoing, the equation of any ray "a" is $y = 64.92/a^2\ x$, the x coefficient being the tangent of the angle with the X axis. Also it results that boundary intersections to locate the rays have scale equations on $x = 10$ in. of $y = 649/d^2$; and on $y = 8$ in. of $x = d^2/8.115$ the method consists of stretching the abscissas out until the curve becomes a straight line, and is known as anamorphosis. See PRODUCT ENGINEERING, December 1935, page 459.

For thin plates the chart is crowded, but it will be noted that the safe load



per sq ft p on a 4 ft $\frac{1}{2}$ in. plate is the same as that on a 2 ft sq $\frac{1}{4}$ in. plate, and more conveniently read.

—CARL P. NACHOD
Nachod & U. S. Signal Co., Inc.

To Fill the Dents

To the Editor:

We would be interested in receiving further information relative to the "powdered aluminum cold solder" referred to in the "Highlights" section of your May issue.—D. M. IRVING
Canada Vulcanizer & Equipment Co., Ltd.

Ed.—As we stated in the "Highlights" section, the new "cold" solder will

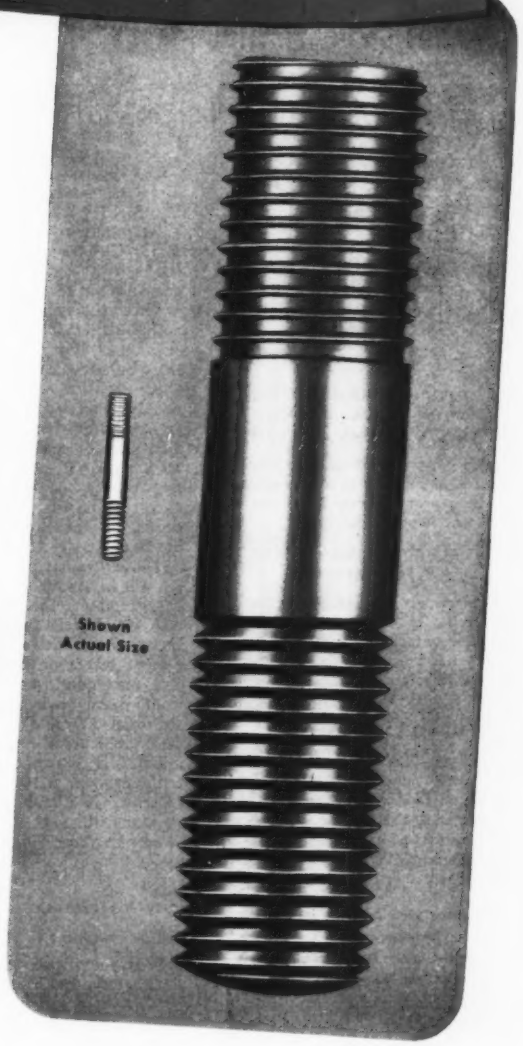
They're both LOK·THRED

NOW . . . get Lok-Thred's greater strength . . more positive locking action . . in *any* size stud, bolt or screw

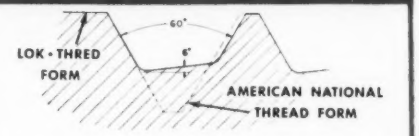
Are you making full use of LOK-THRED'S proved advantages—and its availability in any size or type of threaded fastener?

The revolutionary LOK-THRED design locks securely and becomes tighter in service . . . has much higher fatigue limits and is stronger in both tension and torsion than ordinary American National Threads...does not require selective fits.

These and other LOK-THRED features may offer important application advantages in your products. For full information, write for LOK-THRED booklet, today.



SEE THE DIFFERENCE!



Note Lok-Thred's larger cross section . . . and flat root surface instead of a relatively sharp "V" . . . as compared to the American National Thread form. Here's the secret of Lok-Thred's greater strength.

1949 NATIONAL AIR RACES
SEPT. 3-5
CLEVELAND

National Headed and Tubular Products

THE NATIONAL SCREW & MFG. CO.
Cleveland 4, Ohio

Pacific Coast: National Screw & Mfg. Co. of Cal.
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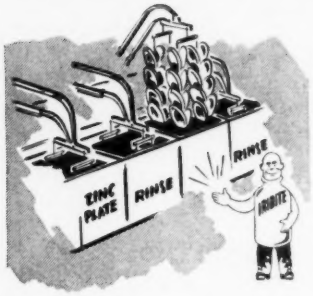
Now--a one dip

IRIDITE

bright finish for

AUTOMATIC ZINC PLATING



COMMON CHEMICAL ADDITION ELIMINATES CAUSTIC RINSE—PERMITS AMAZING LOW COST

The one-dip Iridite Bright treatment for standard automatic zinc plating machines has been proved successful and is now being used in production runs.

RESISTS CORROSION—PROTECTS FROM STAIN

This amazingly low cost protective and brightening process produces a shining stain-free surface with good corrosion resistance . . . utilizing only the normal number of tanks after the zinc plating operation: rinse, Iridite, rinse.

SIMPLE TO OPERATE—NO BLEACHING DIP

This special one-dip Iridite Bright is a non-electrolytic chemical solution . . . operates at 80 to 85° F . . . with no specially trained personnel . . . equally adaptable to bulk plating of parts. Eliminates need for second or bleaching dip.

Whatever your problem in finishing zinc or cadmium — there's an Iridite to do the job. For details, write—wire—or 'phone.

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find its greatest application in the filling of dents and holes in sheet metal, such as automobile bodies.

The material is doughlike—about the consistency of plastic wood. It is applied with a spatula or wiper, and dries in about thirty minutes. When sanded smooth, it is a good base for paint, enamel or lacquer coatings. Write to the maker, Reynolds Metals Company, at 2500 South 3rd Street, Louisville, Ky., for complete details.

What Size Receiver?

To the Editor:

We plan to connect the discharge of our four compressors into a common receiver. These compressors are 15 x 11 in., operate at 300 rpm at 540 cfm, and are single cylinder, double acting.

According to the ASME National Board Code, an R-10, 5 x 14 ft receiver with a content of 275 cu ft, and with an inlet and outlet of 12 in. is recommended for 3,000 cfm. This is the size that we have tentatively selected as it is the next size larger than our requirements. Is this size O.K?

Our compressor discharge lines will be 6 in. in dia, connecting into a common manifold. The manifold will be 10 in. in dia for connection with the first two machine discharge lines, and 12 in. in dia for the other two; continuing in this size to connect with the receiver.

The writer has been unable to find any rule in handbooks as to the method of determining the size of receiver to be used in relation to capacity and speed of one machine or a combination of several machines of different bore, stroke and rpm. For example it would seem obvious that a different size receiver would be required for a compressor with four double acting cylinders at 400 rpm than one double acting cylinder at 100 rpm with equal capacity. No doubt the reader can straighten this out. —A. OLSON
Chief Engineer, The Pierce Glass Co.

How to Harden a Nail

To the Editor:

Will you please send information about a ten-penny nail used as a center punch as described in the May "Highlights" section. —LLOYD B. BENHAM
Porter-Cable Machine Co.

Ed.—The hardening material used in this process (called Hi-Speed-It) penetrates the hot metal and changes the chemical composition of the surface, thus producing a fine case-hardening

IT takes people to make springs. Ours are specialized, highly trained, long-experienced people—well qualified to give you the finest in spring craftsmanship.

Our engineers too, are an important reason why you'll like Accurate Spring Service. They're old hands at springmaking . . . they've developed manufacturing systems and procedures that enable us to handle your jobs with the greatest speed and efficiency.

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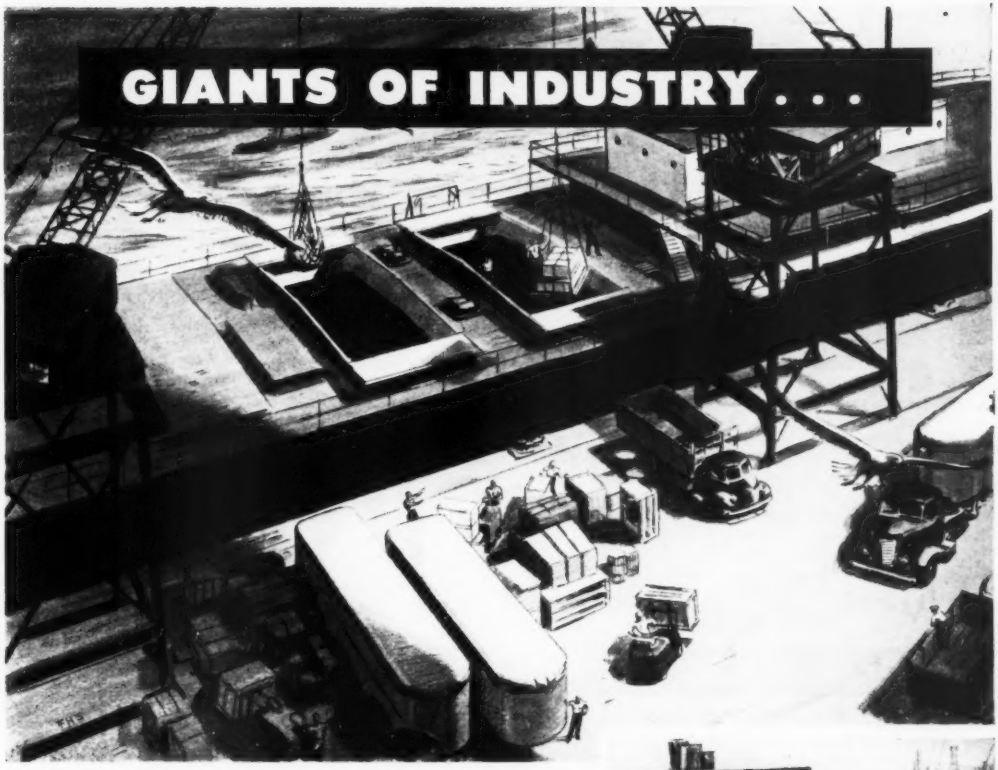
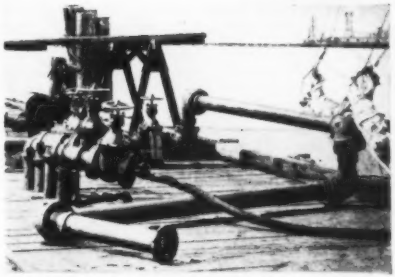


. . . AND BARCO JOINTS KEEP THE FLUID LINES *FLEXIBLE*

Because there is always movement—vibration, expansion, contraction—in any fluid-conveying system, Barco Flexible Joints are needed to provide responsive, compensating movement through every angle. Everywhere in industry and transportation, you will find Barco protecting the arterial systems which convey oil, gasoline, air, water, steam—the life-blood of America's industrial body. For more complete engineering information, write to Barco Manufacturing Co., 1827D Winnemac Ave., Chicago 40, Illinois. In Canada: The Holden Co., Ltd., Montreal, Can.



BARCO JOINTS ON WHARF LOADING LINES combine complete flexibility with long life. Also Barco Joints on loading and unloading lines are available in magnesium which permits extreme ease of handling because of their light weight.

BARCO FLEXIBLE JOINTS

Not just a swivel joint . . . but a combination of a swivel and ball joint with rotary motion and responsive movement through every angle.

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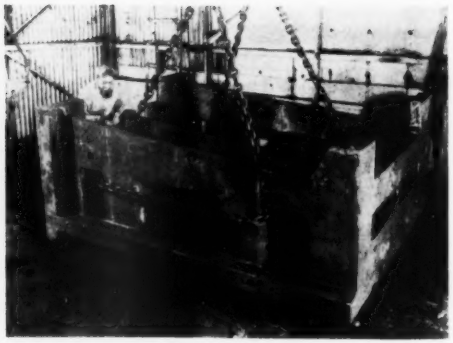
"MOVE IN EVERY DIRECTION"

WHAT'S THE FINISHED COST?



In relation to the cost of machining this 18½-ton angle plate, a little difference one way or the other in the price of the casting itself is of small consequence. The chief consideration is the character of the casting—whether it will require the maximum or minimum of finishing.

If a sound, accurate casting costs more, it is worth more because of the savings in the machine shop. On the contrary, a distorted and defective casting entails so much extra finishing cost that it is expensive at a ridiculously low price.

Advance Castings are bought by customers who think in terms of the finished product. Yet they are keenly aware of casting prices and carefully check our quotations. They pay us only what they think Advance Castings are worth—and our business continues to grow.

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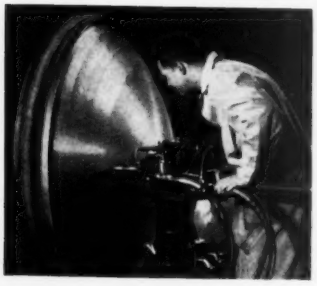
Metal Spinning



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Products Engineered and Manufactured

effect. Since the core of the material (a nail in this case) is unaffected, the operation results in a tough, ductile piece with a hard case.

To give another example, a piece of soft reinforcing rod for concrete has been hardened to serve as a cold chisel in recent tests. You can find out more about this hardening compound from Carbon Products Company, 60 East 42nd Street, New York, N. Y.

What About Conductive Rubber

To the Editor:

The other day I heard a Dr. Robert Britton broadcast from WMCA, that among latest developments in rubber engineering a rubber compound has been developed that conducts electricity. If you are familiar with this new product I would appreciate it very much if you would advise me where I can get information on this subject.

—STEN R. JOHANSON
New York, N. Y.

Ed.—This interesting material is not absolutely new, but it doesn't seem to be too well known to engineers. During the last war this rubber was used to dissipate static electricity in special truck tires for use in munitions factories. Still later, it has been used as a rubber mat to provide a heated floor in chicken coops. You can get full details from U. S. Rubber Co., 191 Hudson St., New York, N. Y.

More Light on That Floodlight

To the Editor:

On pages 7-8 of the May 1949 PRODUCT ENGINEERING "Highlights" section, there is a brief paragraph about a powerful photographic floodlight. The details mentioned suggest that this may be the lamp for which I have searched many months in vain. Please tell me more about it: at least its name and type number and where I could buy one.

I would like to get a complete specification of the lamp characteristics, together with quotations of price and delivery time. —ROBERT E. MCCOY
Consulting Engineer

Ed.—This new lamp is designed for use as a research, design, and development tool. It should replace many makeshift flood lamps that have been used in the past for high-speed motion picture photography. It resembles a sun lamp or heat lamp in shape. With a face five inches in diameter, it throws a beam with an 18 degree spread,

BACK IN THE 1880's

WHEN THE FIRST ELECTRIC ELEVATOR WAS INVENTED

Koven

WAS MAKING INDIVIDUALIZED EQUIPMENT PARTS

Know-how comes from experience. In our case, 68 years of designing and manufacturing individualized equipment parts has given our engineers and craftsmen the time-perfected techniques which enable them to turn out the specific part or parts you require in less time and often at a lower cost than they could be made in your own plant. KOVEN has made possible vast savings for many manufacturers of equipment throughout the country. If you write or call us now, we shall be glad to help you solve your own production problems—no obligation. Our two modern plants are equipped with machine, welding, plate and sheet metal, galvanizing and painting shops. X-ray inspection insures quality control.

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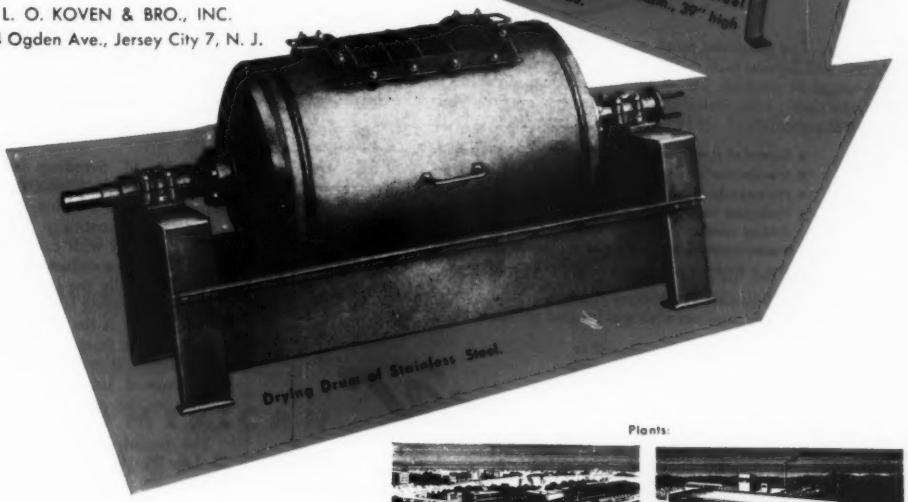

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PRODUCING METAL TUBING

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- Control of raw stock—satisfactory composition is assured before processing.
- Metallurgical control throughout the full production cycle.
- Planned cold drawing schedules—to handle large production runs and repeat orders.
- Controlled atmosphere annealing between each drawing to assure clean, bright finished tubing.
- Visual inspection and laboratory testing of each order to guarantee only tubing that is dimensionally and metallurgically accurate.

Carefully selected distributors, located in all principal cities in the U. S. and Canada, have qualified representatives who will be glad to discuss your tubing needs.

Do you have a copy of Bulletin #31? We will be glad to send a copy at once.

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lighting a four inch square area at a distance of 18 inches.

To withstand the intense heat it generates, the lamp is constructed of heat-resistant glass, and its reflector bowl is coated with silver. Requiring no auxiliary equipment, the lamp fits into an ordinary socket. It has a burning life of six hours. Further information can be obtained from General Electric Co., Nela Park, Cleveland 12, Ohio.

Sorry

To the Editor:

PRODUCT ENGINEERING, March 1949, page 7, top, right-hand column, re: Brookhaven's Cosmotron:

Quote—"Protons . . . . . will travel 120,000 miles in half a second."

This gives a rate of 240,000 miles a second. Light propogation is about 186,000 miles per second.

What gives here? Or is this only an acceleration rate and 120,000 miles per second the terminal velocity?

—DR. R. H. HOBROCK
Bundy Tubing Co.

Ed.—Our mistake the speed of 120,000 miles per second is correct—not per half second as we stated.

The Chairman of the accelerator project, Brookhaven National Laboratory, writes, "In our particle accelerator the protons enter the circular vacuum donut at a speed of roughly 17,600 miles a second and after a short time (about one second) they are accelerated to a speed of approximately 120,000-150,000 miles per second."

Clutch Controversy

To the Editor:

Mr. N. M. Sverdrup in his "Accurate Solution for Disk-Clutch Torque Capacity" states that his formula (1) is not mathematically correct and should be used with care.

It is a curious circumstance that this formula is really the ideal one to use, although appearing to be only approximate. Eq (6) is the standard formula and it will be found that a clutch designed from it will lose about $\frac{1}{6}$ of its calculated torque, depending, of course, on the ratio of inner to outer radius.

The trouble is that Mr. Sverdrup does not distinguish between the brand new clutch with perfect surfaces and the clutch whose facings have been worn with use. That is, he has assumed the unit force, or pressure, as a constant. This is not true during the wearing process. Wear will tend to be uniform all over the clutch lining and plate; that is, the rubbing factor, pV,

DOGHOUSE!

A designer . . . plagued with production costs of a fluorescent reflector housing . . . solved the double problem of lightness and strength plus fast manufacture. He hadn't considered the economy of finished parts by extrusion . . . had kept magnesium in the doghouse.

But he asked Aluminum Company of America, light metal headquarters, for help. He found that fellow manufacturers every month are using over a million pounds of magnesium. He found that magnesium machines fast, and has a high strength-weight ratio . . . . that common sense shop practice makes handling magnesium no problem.* He got technical advice and books about designing and fabricating magnesium. Now, instead of fabricating parts like this, he buys immediately available Magnesium Extrusions like this. His production time is slashed. His lighter, stronger reflector housing is outselling competition.

*No change in insurance rates.

These two, free books on magnesium and our broad technical experience can help your products, too. Write Aluminum Company of America, sales agent for American Magnesium products, 1702G Gulf Building, Pittsburgh 19, Pennsylvania.

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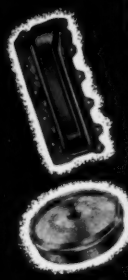
Char-Lynn ALUMINUM DIE CASTINGS



BY a special Char-Lynn process, heavy section castings can be produced without porosity. Fast, accurate Reed-Prentice machines, manned by able craftsmen, turn out castings of quality. You are assured of permanence of dimension and shape . . . good surface finish . . . time and money saved in your finishing department. *Write or phone for engineering consultation and estimates.*

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Up to 6 pound capacity

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More than 50 years of leadership and experience in developing special purpose cloths for industry. With such a background of experience it is little wonder that Holliston Tracing Cloth is second to none. Try MICRO-WEAVE.

WHY SHOULD WE SEND YOU A GENEROUS SAMPLE OF MICRO-WEAVE TRACING CLOTH?

Is it always *fair* to request a head draftsman or purchasing agent to test a sample? No, not always. When is it fair? Only when the sender is absolutely sure that his sample has something.

That is exactly the case with Holliston MICRO-WEAVE Tracing Cloth. It has won its place on the drawing boards of thousands of customers by the Test Method. Feature points — such as uniform transparency, erasability, cleaner sharper blueprints, saving in time and labor costs — were tested on drafting boards and found to be *true*. We have a right to ask you to request samples of MICRO-WEAVE Pen and Pencil Tracing Cloth, because in so doing you will do yourself a favor.

THE HOLLISTON MILLS, INC.
CHICAGO NORWOOD, MASS. NEW YORK

will be constant. Since V is proportional to the radius,

let $p\,r$ = constant, say C. Thus, we have pressure as a function of the radius, $p = \frac{C}{r}$ where r is the variable radius.

let F = axial force on the clutch plates If unit force, p, is variable, then

dF equals $p\,dA$, or $\frac{C}{r} dA$, and $F = 2\pi C (r_o - r_i)$

where r_o and r_i are outer and inner radii respectively.

The work per revolution of the clutch is

$dW = 2\pi r p M 2\pi r dr$ or $4\pi^2 r^2 M p dr$,

and substituting for p its value in terms of r,

$$W = 4\pi^2 CM \int_{r_i}^{r_o} r\,dr = 2\pi^2 MC (r_o^2 - r_i^2)$$

and substituting the axial force,

$F, W = \pi MF (r_o + r_i)$

If R is the mean radius of action, equating the work done to the product of force $\times$ distance,

$2\pi RMF = \pi MF (r_o + r_i)$

or,

$$R = \frac{r_o + r_i}{2}$$

which is the arithmetical mean. Then,

$$T = \frac{FM}{2} (r_o + r_i)$$

It is better to use this formula rather than charge the loss of torque to the coefficient when the constant pressure formula is used.

Sverdrup's correction factor, being $\equiv 1$, indicates a torque higher than will obtain, by exactly the value of ϕ.

—HERBERT F. BARIFFI
New Haven, Conn.

To the Editor:

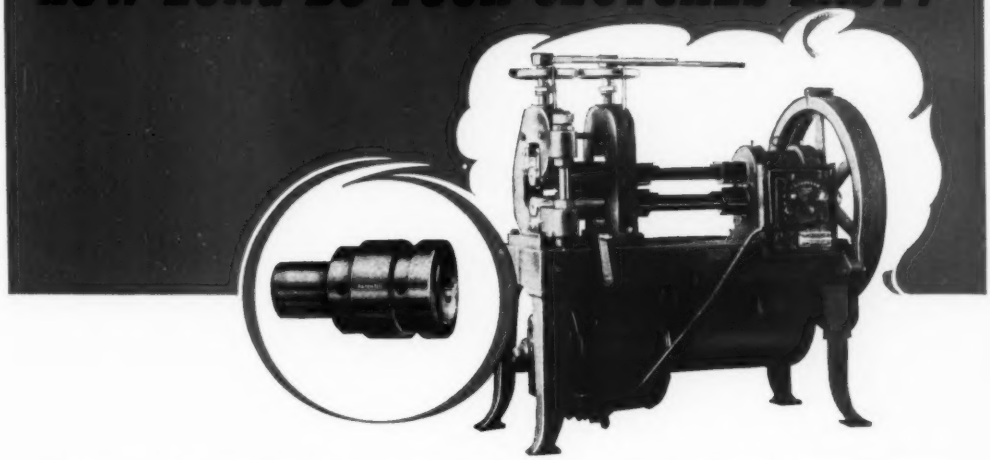
It should be pointed out in connection with Nils M. Sverdrup's article in the May 1949 issue, page 159, that one of two possible assumptions must be made when designing a plate clutch. Mr. Sverdrup assumes that the axial force is uniformly distributed over the plate surfaces so that pressure p is a constant. This condition may be difficult to achieve in practice.

The other method assumes all parts to be completely rigid so that the wear over the clutch surface is constant. Perhaps the correct method would lie somewhere between these two methods. Numerically the results are not very different. When D_o is three times D_i, the latter method will indicate that the torque capacity is about 8 percent less than the first method.

Reference can be made to "Design of Machine Elements," Prentice-Hall, Inc., 1948. —M. F. SPOTTS
Northwestern University

THE $64.00 QUESTION....

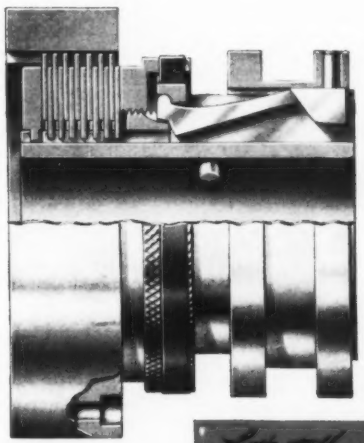
HOW LONG DO YOUR CLUTCHES LAST?



We have long known that our original clutch . . . the JOHNSON . . . was a good one but actual proof arrived the other day from Samuel Kirk & Son, Baltimore . . . "America's Oldest Silversmiths."

They asked for a few replacement parts for Johnson Clutch serial No. 64, which was original equipment in a Reverse Cross Rolling Mill, purchased from the Waterbury Farrel Foundry & Machine Co. in 1904 . . . and is still in use after 45 years of service.

The present Maxitorq Clutch . . . our compact, modernized improvement of the "Johnson"... is the result of skilled designers and careful manufacture by a company that has made clutches, only, for 46 years. We hesitate to guarantee 45 years of service, but assure you of full satisfaction when you select Maxitorq for original equipment, within its capacity . . . to 15 H.P. at 100 r.p.m. Our Engineering service is yours for the asking.



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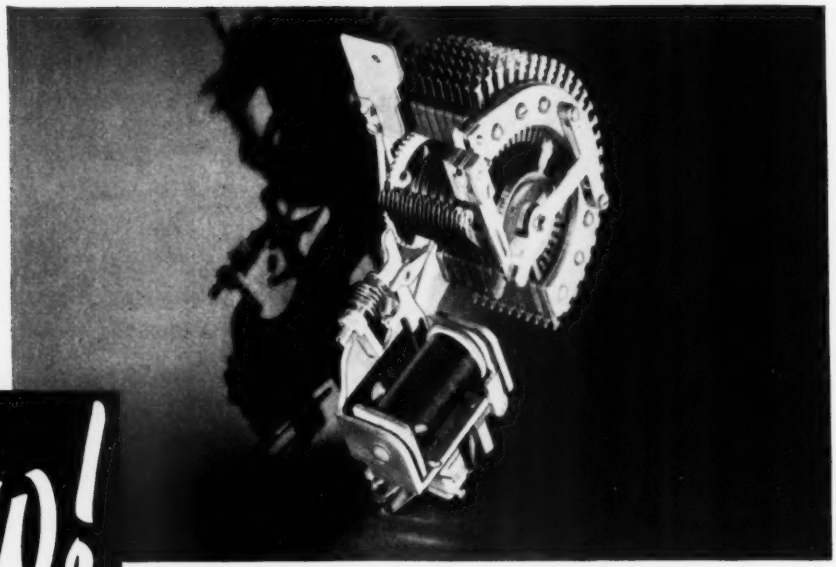

new!

the Type 45 Rotary Switch

70 Steps a Second Speed
Up to 10 (or more) Bank Levels
Only 1 Field Adjustment

For *all* the features you want . . . in *any* remote-control application . . . look to Automatic Electric's Type 45 Rotary Switch!

SPEED . . . it's faster! It carries 10 wipers at 70 steps a second on 46 volts d.c. self-interrupted, or at 35 steps a second, externally interrupted.

CAPACITY. . . it's greater! Ten or more 25-point bank levels can be accommodated on the same frame, and single ended wipers can be provided for 50-point operation.

ADJUSTMENT . . . it's simpler! A rare readjustment of the interrupter springs is all that's normally required.

OPERATION . . . it's smoother! With an even load on *all* contacts, the Type 45 runs without galloping; there's no chatter or bounce.

ADAPTABILITY. . . it's more useful! With more levels, faster speed and 25- or 50-point operation, it's suitable for a wider variety of control applications.

For complete information on this switch that's new and better, write for our new circular.

the Class "B" Relay

Here's a new relay, too, that can be used for ordinary relay service—opening, closing or switching circuits—and for extremely high-speed operation. Independently operating twin contacts assure perfect contact operation. Contact points are dome-shaped to maintain uniformly low contact resistance. They may be arranged in one or two pile-ups with a maximum of 16 contacts on 13 springs in each pile.

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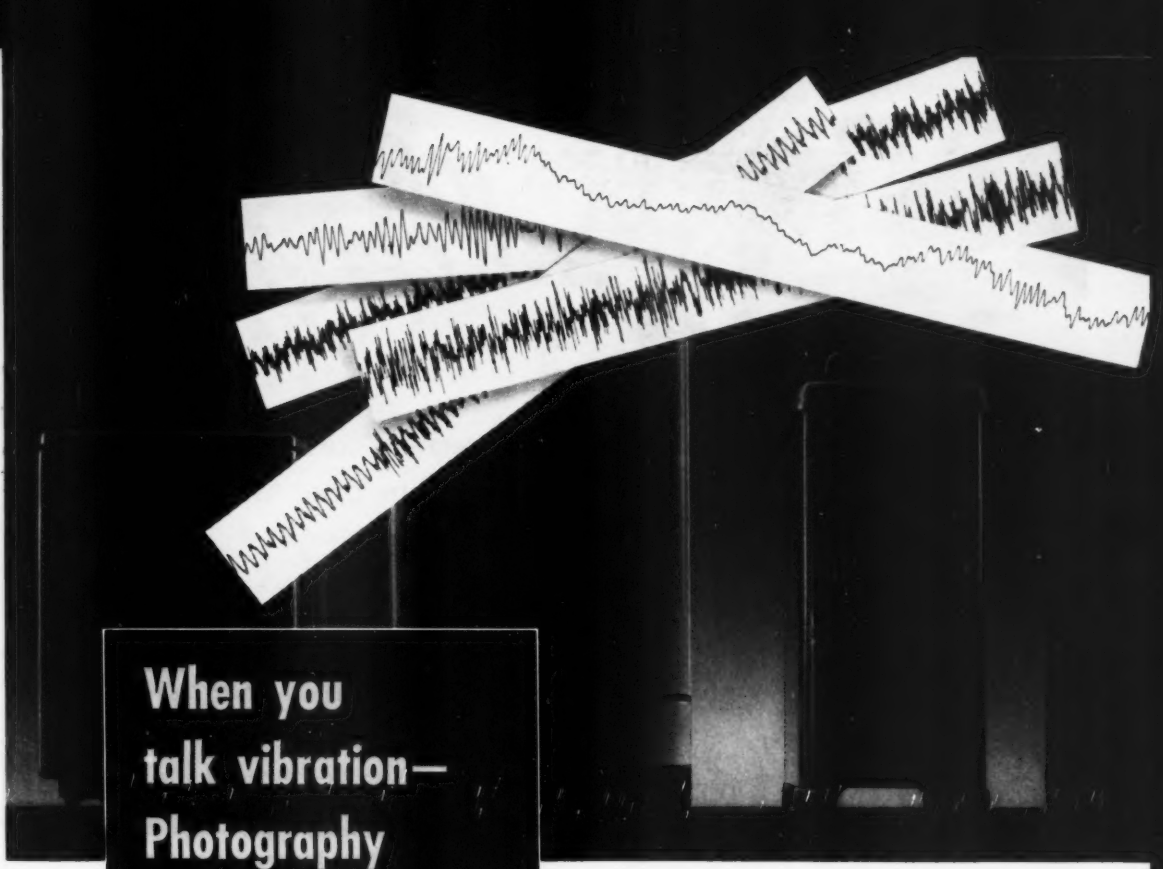

When you talk vibration— Photography clinches arguments

Photographic records of oscillograph traces which tell how electrical appliances are behaving—foretelling how well they'll sell and work and how long they'll last.

YOU CAN put your finger right on performance peculiarity revealed by the line that an oscillograph draws—take time to study it, discuss it with others. That is, if you record it photographically. It's the way to uncover wrecking vibration and trace its cause—to drive toward a finer, more salable product.

This is one of today's important uses of photography in industry. It is typical of the way photography is used to improve a design or streamline a process.

And there are many more. Radiography, for example, can check internal structure for flaws. Photomicrography can show a metal's make-up—indicate its strength. High speed movies slow down the fastest mechanical action for careful study and so can reveal faulty operation too fast to see otherwise.

In these ways, and in many more, manufacturers, engineers, and scientists use photography to advance their work.

Photography can serve you well. In your plant, your laboratory, your office, there are matters both unusual and routine that photography can simplify and speed up. So it will pay you to write to Kodak for information when you come across a problem on which you think photography can help.

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Rochester 4, N. Y.

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Functional Photography

ADVANCES BUSINESS AND INDUSTRIAL TECHNICS

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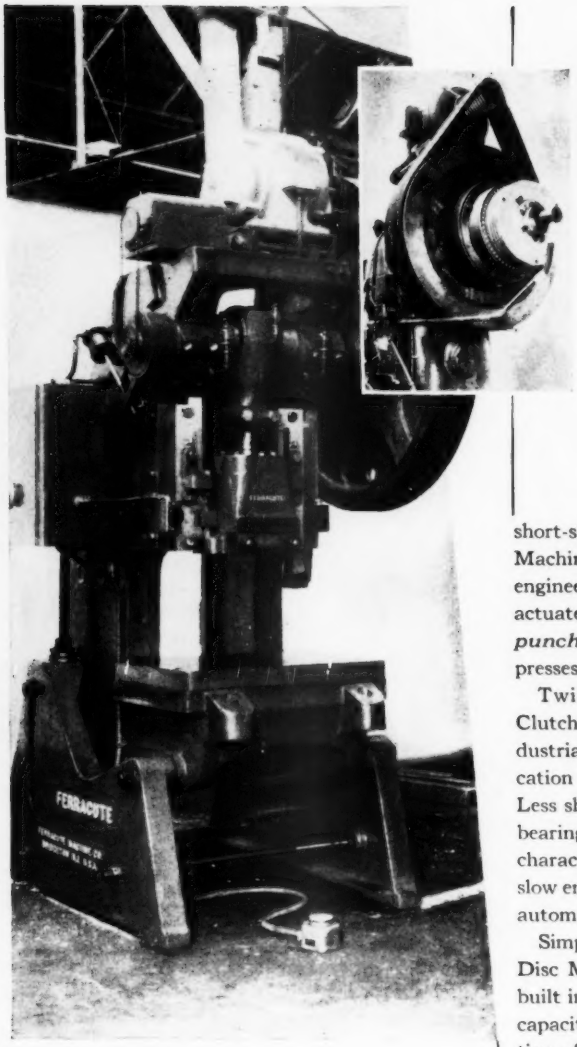


100% Faster Punch

Obtained from Twin Disc Model P Air-actuated Clutch

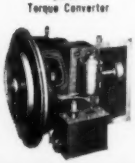
The problem was how to increase the short-stroke speed on a punch press. The Ferracute Machine Co., Bridgeport, N. J., called in Twin Disc engineers . . . who recommended Twin Disc Air-actuated Clutches. The result . . . *100% faster punch*. Now their complete line of 40 to 110 ton presses uses Twin Disc Air-actuated Clutches.

Twin Disc Models P and PH Air-actuated Clutches—standard on many types of heavy industrial equipment—offer advantages in any application where remote control operation is desired. Less shaft space is needed, permitting closer shaft bearing center distances. They have ideal operating characteristics: high torque capacity . . . fast or slow engagements . . . the ability to absorb heat . . . automatic adjustment for longer wear-life.

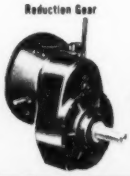
Simple in design, rugged in construction, Twin Disc Model P and PH Air-actuated Clutches are built in a wide range of sizes (14 to 42 inches) and capacities (75 to 1325 hp), permitting the selection of exactly the right clutch for every installation. Write for Bulletin 139-B. TWIN DISC CLUTCH COMPANY, Racine, Wisconsin (Hydraulic Division, Rockford, Illinois).

Ferracute 75-ton Punch Press equipped with Twin Disc Model P Air-actuated Clutch.

Close-up of Model P Clutch installed on Ferracute Punch Press.



TWIN DISC
CLUTCHES AND HYDRAULIC DRIVES



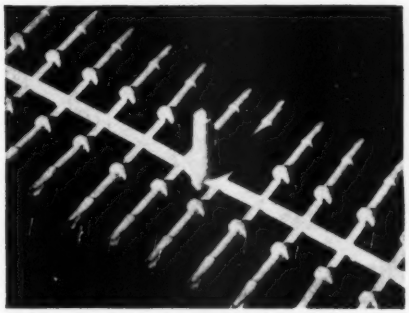
SPECIALISTS IN INDUSTRIAL CLUTCHES SINCE 1918

Reddi-wip whipped cream dispenser with plastic valve stem and cap molded of Koppers Polystyrene 7. The valve stem is molded with a very small gate—almost a pin point.

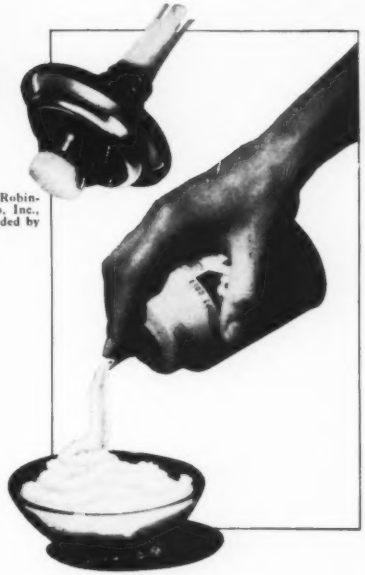
200,000 Reddi-wip parts a day

made on a 20-second molding cycle with

Koppers Polystyrene



Valve assembly made by The Robinson Company for Reddi-wip, Inc., St. Louis. Plastic parts molded by Detroit Plastic Engineering.



● Women get a "bang" out of using this clever whipped cream dispenser. All they do is shake it up, press the plastic valve and out comes the whipped cream. There is no tiresome whipping . . . no dishes to wash . . . and no waste of whipped cream. What's left can be used some other day.

Sales of Reddi-wip cream have been tremendous. Six million of these cap assemblies have already been made. More are being produced by Detroit Plastic Engineering at a rate of 200,000 per day. The 20-second molding cycle obtained with Koppers Polystyrene 7 makes this high production possible. The molder is well pleased with this fast-flowing, fast-setting material and he gets a high percentage of perfect parts.

Other factors leading to the selection of Koppers Polystyrene were its freedom from taste and odor, unlimited choice of color and low cost. What's more, this same valve assembly can also be used for such things as ketchup, mustard, and other items.

If you want to speed up production, cut costs and make a better product, use Koppers Perfected Plastics.

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Chemical Division **Pittsburgh 19, Pa.**
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RUST RESISTANT • BLACK LUSTRE FINISH

Acts as a lubricant, retards corrosion, prevents rusting. H-K Dowel Pins, made from H-K Special Analysis Alloy Steel, are hardened, carburized, double precision ground. Every dowel pin 100% individually inspected. Available from Stock.

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NEW CATALOGS AND BULLETINS

A Reader Service To Help Keep Your Library Up-to-Date

(1) ELECTRICAL STEEL SHEETS — Carnegie-Illinois Steel Corp., 2687 Carnegie Bldg., Pittsburgh 30, Pa. Engr. Manual 3, 160 pp. Curves and tables give exhaustive data on electrical steel sheets made in coils and cut lengths for electrical devices requiring laminated core materials.

(2) PAPER DIELECTRIC CAPACITORS —Cornell-Dubilier Electric Corp., South Plainfield, N. J. Catalog, 30 pp. JAN specifications given for line of capacitors which have a voltage range from 100 to 12,500 v dc, and from 0.001 to 10 mfd in capacitance.

(3) FORGING RODS AND SHAPES—Titan Metal Mfg. Co., Bellefonte, Pa. Folder, 4 pp. Gives physical properties and chemical composition of ten brass and bronze alloys. Also, illustrations of typical forgings made from them.

(4) METALLIZING — Metallizing Engineering Co., Inc., 38-14 30th St., Long Island City 1, N. Y. Bulletin, 8 pp. Pictures and text show how zinc or aluminum metallizing process is used to stop corrosion in a variety of products.

(5) TIMING DEVICES—M. H. Rhodes, Inc., 30 Bartholomew Ave., Hartford, Conn. Folder, 6 pp. Description and specifications for 15 types of automatic timing devices for washing machines, stoves, and other such uses. Illustrated.

(6) STRAIN GAGES—The Baldwin Locomotive Works, Testing Equipment Dept., Philadelphia 42, Pa. Bulletin 279, 4 pp. Gives a variety of uses for the SR-4 bonded resistance wire strain gages, which are available in over 100 types, with lengths from 1/16 to 6 inches.

(7) RUBBER ACID HOSE—The B. F. Goodrich Co., Akron, Ohio. Catalog section 5440, 4 pp. Illustrations and specifications for rubber acid hose for discharge, suction and pinch-valve service. Also, recommendations for concentrations, temperatures, and pressures of various acids to give longest service life to hose.

(8) AMMONIA BOOSTER COMPRESSOR —Worthington Pump and Machinery Corp., Harrison, N. J. Bulletin C-1100-B34, 8 pp. Pictures and drawing give details of ammonia booster for refrigeration, which is available in four sizes, with ratings from 5 to 50 hp, and capacities from 58 to 378 cubic feet per minute.

(9) ROTARY AIR MOTORS—Gast Mfg. Corp., Benton Harbor, Mich. Bulletin 449, 12 pp. Shows how 26 product problems were solved by use of rotary air motors. Describes air motors, which come in 2 types and 4 sizes, from 1/20 to 3 hp, and with speeds from 100 to 6,000 revolutions per minute.

(10) FIBERGLAS REINFORCEMENTS —Owens-Corning Fiberglas Corp., Toledo 1, Ohio. Bulletin, 12 pp. Shows uses and gives specifications for fiberglas products, including yarn, cloth, mats and chopped strands for reinforcing plastics. Gives resins and processes used with each type.

(11) MAGNETIC COUNTER — Veeder-Root, Inc., Hartford, Conn. Bulletin G47-59C, 1 p. Gives specifications for series 1248 magnetic counter, which is for low-speed, low-count operations, such as coin machines.

(12) VARIABLE SPEED DRIVE—The Louis Allis Co., Milwaukee 7, Wis. Bulletin 611-D, 16 pp. Describes the Ajustospeed, a standard ac squirrel cage motor integral with an eddy current clutch, which is available in two designs—from 5 to 75 hp at 1,800 rpm and ¾ to 5 hp at 3,600 revolutions per minute.

(13) STAMPINGS AND FORGINGS—The Commercial Shearing & Stamping Co., Youngstown, Ohio. Bulletin, 28 pp. Examples of the company's stampings, forgings, hydraulic equipment, and assembled products. Company makes component parts for other manufacturers.

(14) WING NUTS — Grieg Reproducer Corp., 780 E. 138rd St., New York 54, N. Y. Bulletin, 4 pp. Presents specifications for wing nuts, which vary in size from a No. 4 screw size to 5/16 in. for the junior type, and from No. 4 screw size to ½ in. in senior type. Also shows some zinc die castings and plastic injection moldings of small component parts.

(15) VINYL PROTECTIVE COATING— Dennis Chemical Co., 2701 Papin St., St. Louis 3, Mo. Bulletin, 4 pp. Explains advantages of Perma Skin vinyl corrosion-resistant protective coating, which adheres to metal, wood, stone and brick, to prevent corrosion action of salt water, corrosive atmospheres, or severe climates.

(16) CONDENSER TUBES AND PLATES —The American Brass Co., Waterbury 88, Conn. Booklet, 40 pp. Describes construction and materials used in condenser and heat exchanger tubes and plates. Stresses uses of copper alloys to prevent corrosion. Tabulates physical and chemical properties of various tube, plate, and bolt stock materials.

(17) FORGED STEEL PARTS — Pittsburgh Forging Co., Dept. P, Coraopolis, Pa. Booklet, 64 pp. Describes plant and facilities for doing contract forging of component parts. Stresses engineering, quality and operational control procedures.

(18) CONVEYOR BELTS—The B. F. Goodrich Co., Akron, Ohio. Folder, 4 pp. Shows how the "Griptop" belt conveys material at angles of incline too high for conventional belts. Some materials can be carried up or down 30 deg slopes.

(19) HARDFACING—Air Reduction, 60 E. 42nd St., New York 17, N. Y. Reprint of technical paper, 8 pp. Microphotos and case histories show advantages of the hardface welding of parts subject to wear. Include section on designing for hardfacing process.

(20) MAGNETIC REVERSING STARTERS—Ward Leonard Electric Co., 31 South St., Mount Vernon, N. Y. Bulletins 4310 and 4350, 4 pp. Describes line of ac magnetic reversing starters, across-the-line type, for industrial control of polyphase motors up to 200 hp, 550 v and 60 cycles with 3 phase starters, and single phase motors of 7½ hp, 550 v, 60 cycles with 4 phase starters.

(21) EXPANSION JOINTS — Chicago Metal Hose Corp., Maywood, Ill. Bulletin EJ-49, 8 pp. Explains use of "free-flexing," and "controlled-flexing" corrugated type expansion joints in copper and stainless steel construction. Complete specifica-

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tion for over 200 joints ranging from 4 to 24 in. inside diameter.

(22) DC MOTOR CONTROL—Westinghouse Electric Corp, Box 868, Pittsburgh, Pa. Booklet B-4112, 24 pp. Describes Mot-O-Trol, a four-piece adjustable speed drive for precise control of dc motors operated from ac sources. Specifications and uses given.

(23) EXTRUDED BRAZING ALLOY—Westinghouse Electric Corp., Box 868, Pittsburgh, Pa. Bulletin B-4198, 16 pp. Eight methods of brazing with Phos-Copper are described—gas, dip, incandescent carbon, electric furnace, high frequency induction, arc torch, carbon arc, and spot welder brazing. Alloy can be used with copper, brass, and bronze.

(24) CORROSION RESISTANT ALLOYS—The Duriron Co., Inc., Dayton 1, Ohio. Bulletin 113, 12 pp. Gives chemical and mechanical properties of two high silicon irons which resist corrosion in oxidizing or reducing environments. Gives recommendations for use with 150 corrosives.

(25) INDUSTRIAL CASTERS—Rose Truck and Caster Co., 12400 Strathmoor, Detroit 27, Mich. Catalog C-1-49, 20 pp. Cut-away drawings show construction of medium, heavy, and extra heavy casters which range in wheel diameters from 4 to 10 in. Trailer and stem casters also shown. Specifications given for all models.

(26) HARDFACING WIRE—Wall Calmonoy Corp., 19345 John R. St., Detroit 3, Mich. Folder, 8 pp. Explains use of Calmonoy Spraweld Wire in a combination welding-metallising process. Wire is available in sizes of ⅛ through 3/16 in., and is used in wire metallising guns for precision hardfacing.

(27) TRANSFORMERS—Standard Transformer Corp., Chicago 18, Ill. Catalog, 32 pp. Gives specifications and price list of over 400 input, interstage, driver, output, power, modulation and poly-pedance transformers, and related components.

(28) CASTERS—The Fairbanks Co., 393 Lafayette St., New York 3, N. Y. Bulletin 21-31, 4 pp. Describes construction and uses for series "21" swivel, and series "31" rigid casters which have overall heights from 2¼ to 7¼ in., and carry loads from 90 to 500 lb. Specifications and price list given.

(29) GALVANIZING FLUXES—Hanson-Van Winkle-Manning Co., Matawan, N. J. Bulletin F-100, 8 pp. Tells how to use H VW. M #20 fluxes for hot dip galvanising and hot tinning of wire, small parts, pipe, etc. Full instructions for use and tabulated data given.

(30) EXTREME-DENSITY ALLOY—P. R. Mallory & Co., Inc., Indianapolis 6, Ind. Bulletin, 4 pp. Gives physical and electrical properties, applications, and availability of Mallory 1000 metal, an alloy having a Rockwell hardness of 24-30 "C," density of 606 lb per cu in., tensile strength of 80,000 psi, and electrical conductivity of 14-15 percent I. A. C. S. Metal is used to replace lead, gold, tungsten, and other high-density metals.

(31) PRECISION VALVES—Hanna Engineering Works, 1765 Elston Ave., Chicago 22, Ill. Catalog 251, 16 pp. Pictures and specifications given for foot-operated, hand-operated, speed control solenoid, pilot, and mastair valves which handle pressures up to 500 psi. Valve circuit diagrams also given.

(32) VIBRATION CONTROL—The MB Mfg. Co., Inc., 1060 State St., New Haven 11, Conn. Bulletin, 12 pp. Graphs and charted data on vibration isolators, engine mounts, vibration test equipment, and vibration pickup, exciters and calibrators, and pads.

(33) ACRYLIC MOLDING POWER—E. I. du Pont de Nemours & Co., Inc., 350 Fifth Ave., New York 1, N. Y. Bulletin, 4 pp. Announces "Lucite" HM-140, an improved heat-resistant acrylic molding powder, which can be injection-molded at cylinder temperatures of 360 to 490 F. Mechanical, thermal, electrical, optical, and injection and compression molding properties given.

(34) AIR-OPERATED DEVICES—Mead Specialties Co., Inc., 4114 N. Knox Ave., Chicago 41, Ill. Catalog, 48 pp. Specifications and pictures show construction and uses of 21 air cylinders with strokes ranging from ⅛ to 48 in. Over 20 other air-operated devices shown. Price list included.

(35) SINGLE PHASE MOTORS—Century Electric Co., St. Louis 3, Mo. Bulletin 942, 8 pp. Cut-away and component-part photographs show construction of repulsion start, induction, brush lifting, single phase motors ranging from ½ to 20 hp at 230 volts.

(36) HIGH-SPEED AC GENERATORS—Allis-Chalmers Mfg. Co., 1002 S. 70th St., Milwaukee, Wis. Bulletin 06B6021B, 8 pp. Describes both bracket and pedestal type bearing synchronous generators ranging from 93.5 to 800 kva. Also features voltage regulators and controls.

(37) TIMING DEVICES—Haydon Mfg. Co., Inc., Torrington, Conn. Catalog 321, 20 pp. Presents line of synchronous timing motors, chart drives, timing devices, and clock movements. Lists speeds, voltages, frequencies, shaft sizes and special variations available for timing motors.

(38) HYDRAULIC CONTROL HOSE—The B. F. Goodrich Co., Akron, Ohio. Bulletin 4030, 4 pp. Cut-away photos show construction of wire-braided rubber hose for working pressures from 300 to 5,000 psi. Method for calculating bending radii for various hose sizes and illustrations of reattachable couplings also given.

(39) SOLDERLESS ELECTRICAL TERMINAL—Aircraft-Marine Products, Inc., 1621-75 N. Fourth St., Harrisburgh, Pa. Bulletin, 8 pp. Pictures, specifications, and samples of terminals made into a continuous strip for automatic crimping. Terminals made in a variety of types for wire sizes from 22 to 10, inclusive.

(40) PAPER PULLEYS—Rockwood Mfg. Co., Inc., Indianapolis, Ind. Catalog, 6 pp. Gives price list and specifications for over 1,100 paper pulleys from 1⅛ to 14 in. in dia, with belt widths from 1⅛ to 12 inches.

(41) BEARING LOCK NUTS AND WASHERS—Whittet-Higgins Co., Box 1613, Providence 1, R. I. Reprint sheets from SAE Handbook to be published late 1949, 5 pp. Tables give specifications for SAE standard ball bearing and taper roller bearing lock nuts, shafts, and washers.

(42) INSULATING MATERIAL—Owens-Corning Fiberglas Corp., Toledo 1, Ohio. Bulletin, 8 pp. Announces "Aerocor," a thermal and acoustical insulation for use from sub-zero to 600 F and weighing 1¼ oz per square foot. Material available in widths of 12, 36, 54, and 72 in. in rolls from 80 to 210 ft long.

(43) ELECTRONIC CORE-BAKING—The Induction Heating Corp., 181 Wythe Ave., Brooklyn 11, N. Y. Data sheets, published monthly, Nos. 1 and 2, 2 pp. Describes electronic method of baking sand cores and discusses resin core binders.

(44) MERCURY PLUNGER RELAYS—Ebert Engineering & Mfg. Co., 185-09 Jamaica Ave., Hollis 7, L. I., N. Y. Bulletin, 4 pp. Outline drawings, photographs and technical data on relays for current loads up to 25 amps, 115 v, and 25 amps, 230 v; ac motor loads to 2 hp. Also, 2 pole relays for loads to 2 hp and 3 pole for loads to 10 hp, 400 volts.

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For example, note the handle of a soldering gun made on a Stokes press by Weller Mfg. Co. of Easton, Pa. The new design is economical to produce, assembles easily, is more comfortable for the user, and provides improved ventilation by molded-in vents.

Write us for full details on Stokes Advisory Service . . . or better still, send us your problem and let us help you find a practical and profitable solution.

F. J. Stokes Machine Co., 5900 Tabor Rd., Phila. 20, Pa.

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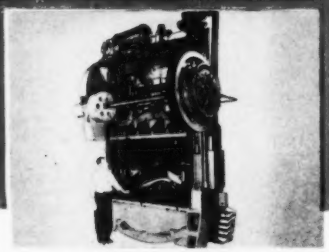
STOKES KNOWS HOW

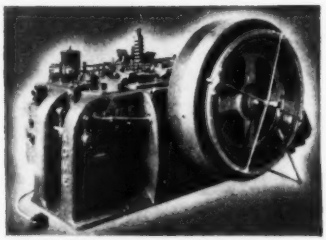
ONLY ONE MOVING PART

in this Fawick Clutch

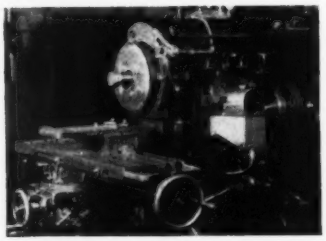
Fawick Airflex Clutch or Brake Type CB



Fawick Airflex Clutch and Fawick Air-Ring Brake conversion on Model 60-D-84 Power Press.



Fawick Airflex Clutch and Fawick Air-Ring Brake on Horizontal Forging Machine by Hill Acme Company, Cleveland, Ohio.



Fawick Airflex Clutch on Brown and Sharpe No. 2A Milling Machine.

The rubber-and-fabric pneumatic tube faced with friction shoe assemblies is the only moving part in this Fawick Clutch. This part naturally stays in perfect adjustment at all times—automatically compensating for wear of the friction shoes.

Job-tested, Fawick Clutches meet the toughest operating conditions in many fields—petroleum, earth-moving, metalworking, rubber, paper, pulp and others.

Write our engineering department for a recommendation of the Fawick elements best suited for your machines. Address Dept. PE.

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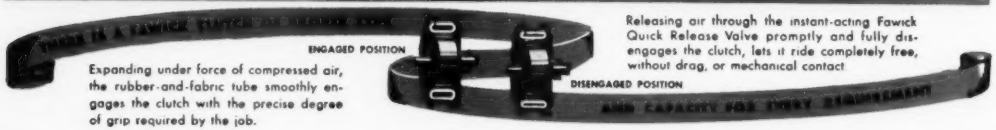
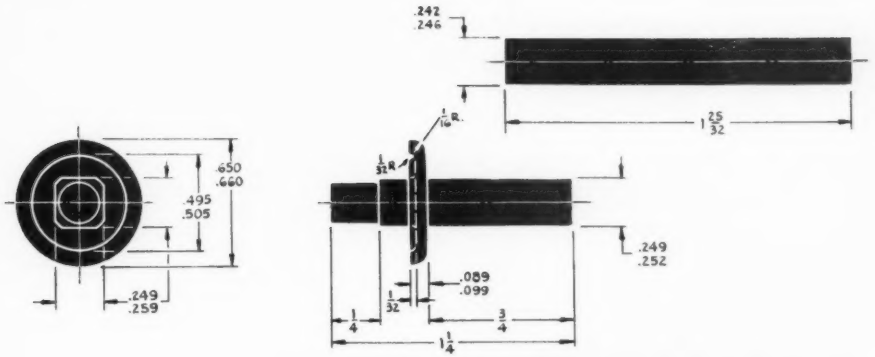
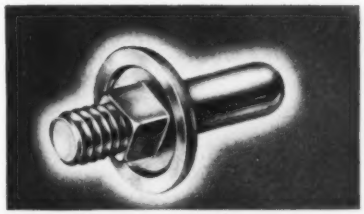


Expanding under force of compressed air, the rubber-and-fabric tube smoothly engages the clutch with the precise degree of grip required by the job.

Releasing air through the instant-acting Fawick Quick Release Valve promptly and fully disengages the clutch, lets it ride completely free, without drag, or mechanical contact





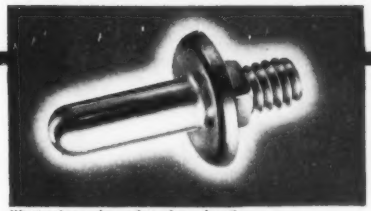


illustration enlarged to show detail

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There is a latitude in the cold heading process that gives designers freedom to usually get exactly the shape and dimensions of a small component part or fastener that meets their needs.

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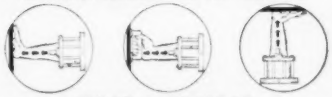

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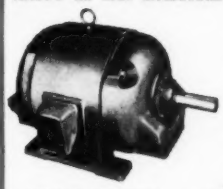

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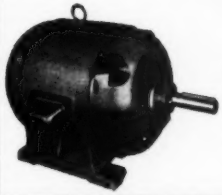

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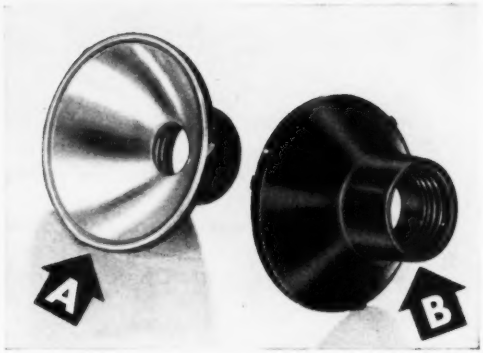

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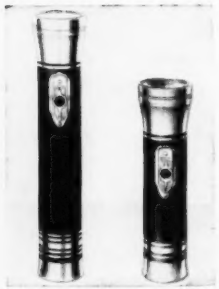

B. Although reflector surface and lamp-seat tolerances are close and there is an internal thread, the parts are molded automatically on one of Auburn's rotary machines. The material is hopper-fed and the molded parts automatically unscrewed from the 20-head hydraulic machine.

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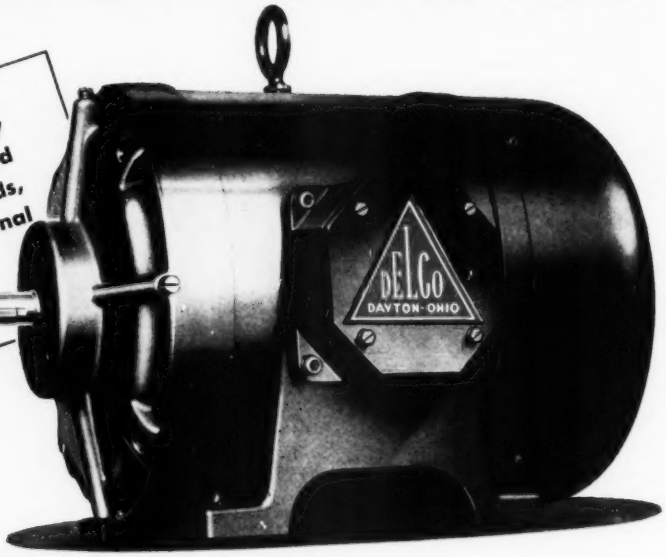

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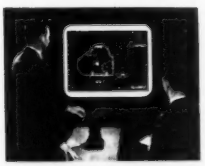

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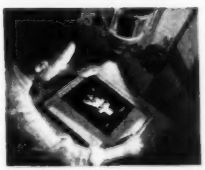

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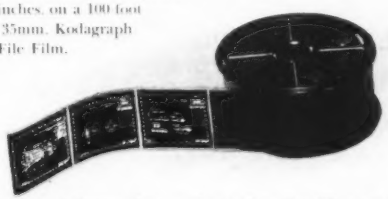

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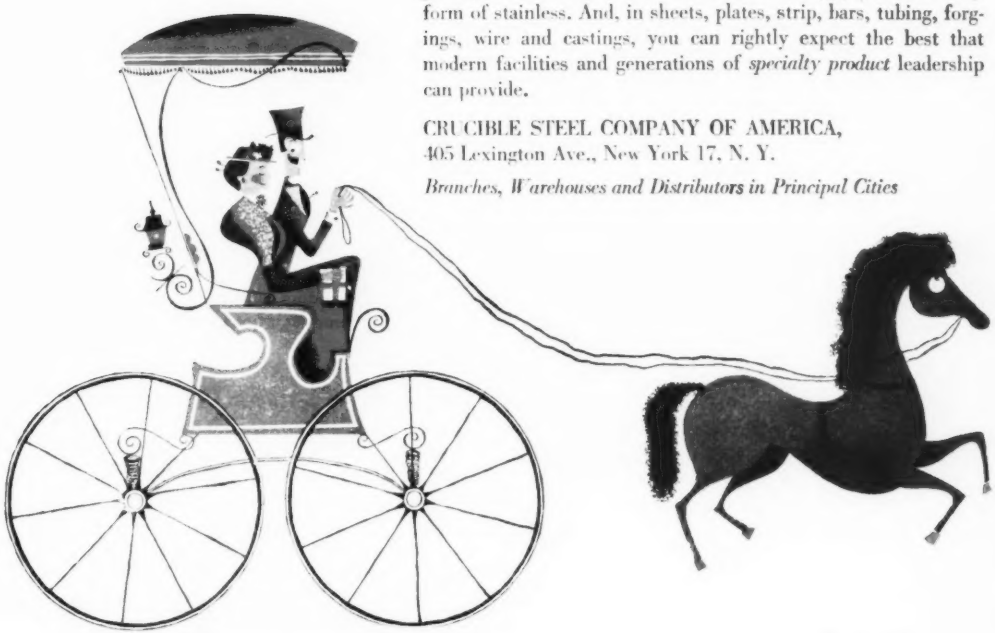

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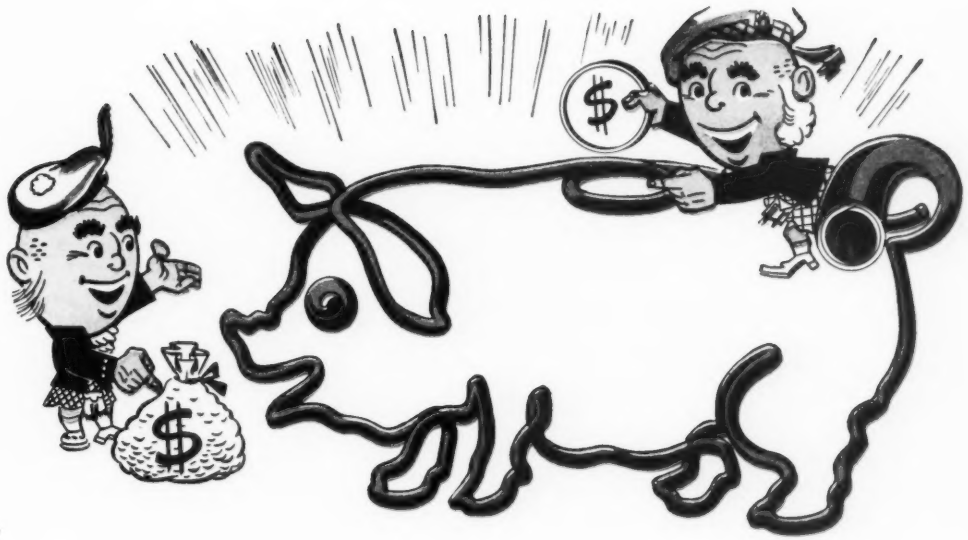


Profit with Bundyweld for your tubing needs

You'll profit in faster production, better design, higher quality or lower cost by using Bundyweld* Steel Tubing.

And here's why!

Bundyweld is made by a patented process . . . *the only tubing that is double-walled from a single strip.* Extra-strong and sturdy, it's long-wearing, ductile and easy to fabricate. The tubing walls are bonded throughout all points of contact, making it much more resistant to vibration fatigue and more leakproof than most other types of tubing. And it's lightweight, thinner-walled, faster-cooling. With all this, you'll find that Bundyweld's cost is surprisingly low.

No other tubing on the market can match *all* the advantages Bundyweld offers. That's why you'll find it in so many diversified fields . . . fields like refrigeration, machine tool, automotive, range, television, radiant heating and tubular toys, to mention only a few.

Why not let this miracle tubing of industry improve your tubular design, structural or functional application? Contact your near-by Bundy representative among those listed below, or write direct to: *Bundy Tubing Company, Detroit 14, Michigan.*

BUNDY TUBING

ENGINEERED TO YOUR EXPECTATIONS

*REG. U. S. PAT. OFF.

WHY BUNDYWELD IS BETTER TUBING

1 Bundyweld Tubing, made by a patented process, is entirely different from any other tubing. It starts as a single strip of basic metal, coated with a bonding metal.

2 This strip is continuously rolled twice laterally into tubular form. Walls of uniform thickness and concentricity are assured by close-tolerance, cold-rolled strip.

3 Next, a heating process fuses bonding metal to basic metal. Cooled, the double walls have become a strong ductile tube, free from scale, held to close dimensions.

4 Bundyweld comes in standard sizes, up to 5/8" O.D., in steel (copper or tin coated), Monel or nickel. For tubing of other sizes or metals, call or write Bundy.

BUNDY TUBING DISTRIBUTORS AND REPRESENTATIVES

Cambridge 42, Mass.: Austin-Hastings Co., Inc., 226 Binney St. • ***Chattanooga 2, Tenn.:*** Peirson-Deakins Co., 823-824 Chattanooga Bank Bldg. ***Chicago 32, Ill.:*** Lapham-Hickey Co., 3333 W. 47th Place • ***Elizabeth, New Jersey:*** A. B. Murray Co., Inc., Post Office Box 476 • ***Philadelphia 3, Penn.:*** Rutan & Co., 404 Architects Bldg. • ***San Francisco 10, Calif.:*** Pacific Metals Co., Ltd., 3100 19th St. • ***Seattle 4, Wash.:*** Eagle Metals Co., 3628 E. Marginal Way • ***Toronto 5, Ontario, Canada:*** Alloy Metal Sales, Ltd., 881 Bay St.

BUNDYWELD NICKEL AND MONEL TUBING IS SOLD BY DISTRIBUTORS OF NICKEL AND NICKEL ALLOYS IN PRINCIPAL CITIES.

Plymetl will help you increase the performance and salability of your products

Haskelite* Plymetl unites plywood's great rigid strength and light weight with the tensile strength of sheet metal. The many users of Haskelite Plymetl find it a material with a flat, smooth, ripple free surface that adds new eye appeal to the products they use it on.

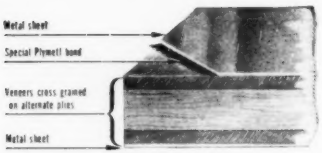
In addition, its great rigidity permits the type of construction that is conspicuous by the absence of numerous or complicated framing members. This factor effects a further saving of deadweight over that already saved through the use of the material itself, and often eliminates man-hours of fabricating time.

If you wish to add a new high standard of eye appeal and reputation building performance to your products—specify Haskelite Plymetl. Write for your free copy of "Plymetl—a material of opportunities."

*T.M. Reg.

CUTS WEIGHT AND BULK — SIMPLIFIES FABRICATION

PLYMETL



Plymetl consists of light gauge metal sheets permanently bonded to one or both sides of a plywood panel. Sheets of zinc coated steel, aluminum or other metals may be used. One type of material may be bonded to one side of the panel, and another type to the other if desired. Panels of Haskelite Plymetl are easily fabricated with simple metal or wood working tools. It may be obtained in a range of thicknesses and sizes to fit specific requirements.

TYPICAL USES

Diesel locomotive side panels, escalator panels, table tops, truck trailer side panels, delivery truck bodies, railway passenger car interiors, bakery proof boxes, bread coolers, air conditioning equipment, low temperature drying ovens, etc.

"ESCALATOR"—T. M. Reg. by Otis Elevator Company

HASKELITE T.M. Reg. *structural materials for men who build better*

HASKELITE MANUFACTURING CORP. DEPT. PE GRAND RAPIDS 2, MICHIGAN
New York Chicago Detroit Philadelphia St. Louis
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Must Understand

MODERN LUBRICATION METHODS

—because today's intense competition demands higher production rates...lower costs...improved product quality...and longer, dependable trouble-free machine life.

With Lincoln Centro-Matic Systems of lubrication, all bearing points are lubricated automatically from a central source and groupings of similar machines are lubricated simultaneously as part of one standard system of lubrication—insuring continuous, dependable machine performance, high production rate, improved product quality... free of costly repairs and downtime, excessive indirect labor and power consumption. Because adequate lubrication is so essential to lower operating costs, more and more machinery manufacturers are installing Lincoln Centro-Matic Lubricating Systems on the machines they are building. These Lincoln Systems insure precise application of clean lubricant with ease and speed and at predetermined intervals and in predetermined quantities. They deserve the most serious consideration of the designing engineer responsible for modern day machine tool efficiency.

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- **CHICAGO**—Lincoln Engineering Co. of Ill.—Calumet 5-6022
- **CLEVELAND**—Lincoln Lubricating Systems, Inc.—Express 4334
- **DETROIT**—Lincoln Engineering Co.—Madison 3484
- **EAST ORANGE**—Lincoln Lubricating Systems, Inc.—Orange 3-3188
- **FORT WORTH**—Fritz Keller—7-7211
- **LOS ANGELES**—Lincoln Engineering Co. of Calif.—Richmond 0151
- **MILWAUKEE**—Lincoln Equipment Service—Division 1191
- **NEW YORK**—Lincoln Lubricating Systems, Inc.—Trafalgar 7-7900
- **OAKLAND**—Lincoln Engineering Co. of Calif.—Higate 6130
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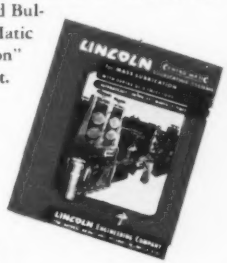
Send for this FREE bulletin!

Your distributor will be glad to give you complete information or contact the Lincoln Sales and Service Office nearest you. Illustrated Bulletin — "Lincoln Centro-Matic Systems for Mass Lubrication" will be sent upon request.



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SANDVIK specializes in "licking" spring steel problems. By analysis, gauge, width and finish each type of **SANDVIK** steel is "tailored" to meet specific physical requirements.

Furthermore, **SANDVIK** spring steels provide a better answer for difficult jobs because they have "body." Body is the inherent "character" of the steel which is influenced by the purity of the raw materials plus the specialized methods and close control maintained by **SANDVIK** throughout processing.

***SANDVIK** specialty steels are available:*

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- **Annealed, unannealed or hardened and tempered**
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- **With bright finish or polished bright yellow or blue**
- **With round edges or square edges**
- **In a wide range of widths**

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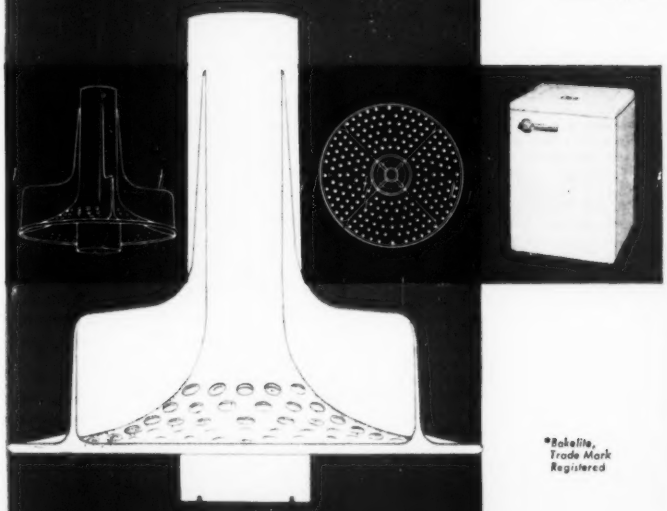
The BENDIX *Economat* AUTOMATIC WASHER AGITATOR



Like leading manufacturers in other industries, Bendix relies on General American's 50 years' of precision production experience and on General American's equipment which includes 2 oz. to 48 oz. injection presses and compression presses up to 2000 tons (71" x 74" platen areas).

General American Plastics can serve you, too — efficiently and economically. Write to General American for information.

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PLASTICS DIVISION

GENERAL AMERICAN TRANSPORTATION CORPORATION

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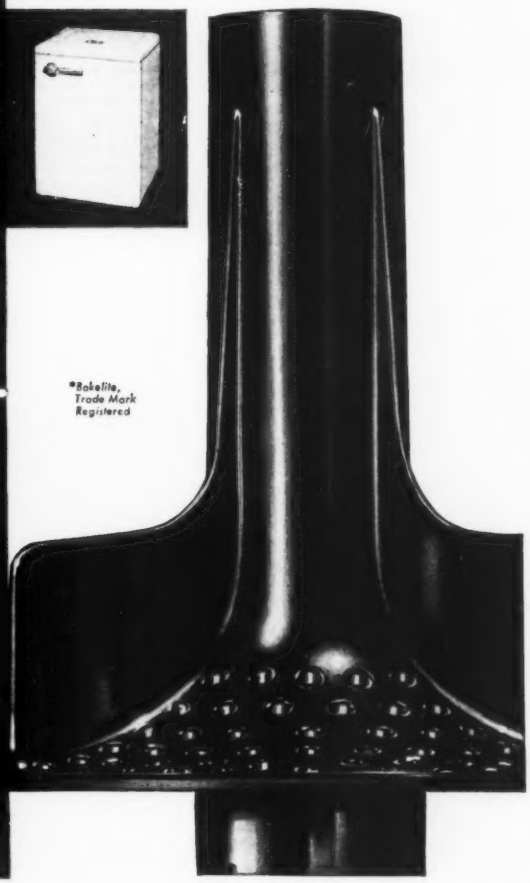
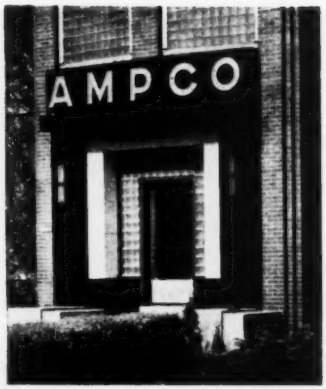
The design called for an agitator with essentially two shafts—one carrying vanes, the other extending below the bottom of the bell. The bell itself required 192 drain holes. The entire agitator was to be driven by a spline shaft requiring a molded tolerance of .0025" plus or minus. And all this had to be done on a piece with a 14" depth of draw!

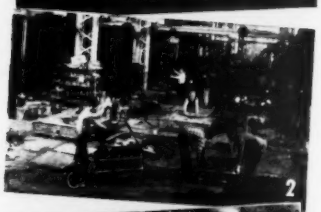
General American built a mold with a solid steel cavity. Using careful mold design and unique methods of venting, General American solved the difficult flow problems. Now the Bendix Economat Bakelite* Agitator is being made in a 4-cavity mold on a 2000-ton compression press and in a single cavity mold on a smaller press.

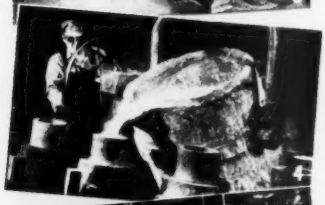


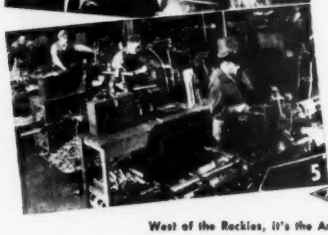
*Bakelite, Trade Mark Registered

AMPCO Versatility helps you Cut Costs









"AMPCO METAL"... a by-word in INDUSTRY — The COMPANY and...a PRODUCT of that company

35 YEARS OF PROGRESS... Founded in 1914 to produce sand castings made from AMPCO METAL... a hi-iron aluminum bronze, the Company has grown steadily and expanded its facilities and the scope of its activities to the point where it is now an organization specializing in the production of non-ferrous alloys and products made therefrom.

Produced under close laboratory control, Ampco aluminum bronze alloys are available as: *sand and centrifugal castings; extruded rod, tube and simple shapes; rolled sheet and plate; forgings; arc and resistance welding electrodes; machined parts; valves; pumps and fabricated assemblies.*

In addition to aluminum bronzes (still the major product) Ampco Metal produces, under the same laboratory control, many other copper-base alloys including: phosphor bronzes; tin bronzes; nickel bronzes; manganese bronzes and Ampco Beryllium-copper.

Ask an Ampco Field Engineer for further details... make full use of our engineering service.

1. **Laboratory Control and Research.**
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West of the Rockies, it's the Ampco West Coast Plant, Burbank, Calif.

PROPER DESIGN— still the most important ingredient

Despite the great advances in the use of alloy steels, the shape and proportions of a part are still of more vital significance than its material.

In an overall view, we should rate Design (1), the choice of the proper Steel (2), and its Treatment (3), in that order of importance. All are, of course, matters of great concern, but if the design is wrong then the proper choice of steel and its successful treatment serve no useful purpose.

What is the metallurgical significance of poor design? It promotes unhealthy stress concentrations and troublesome variations in the proportions of adjacent parts.

To stress the relationship of good design to metallurgical and economic factors, we have prepared a book helpful to designers, showing by sketches a great many factors in good and poor design which influence the behavior of a part in service.

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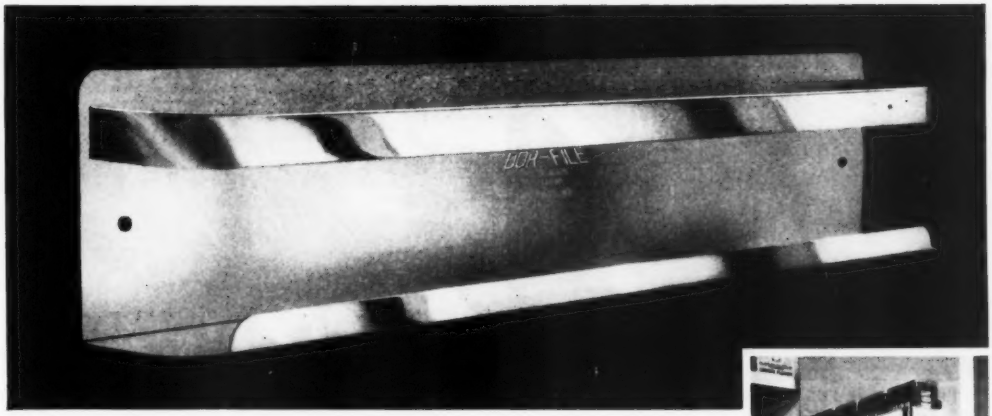

Why you should know about this product

It's a spice rack that fastens to the back of a cabinet door. But more than that—it's an example of how you may improve your product—or increase sales—with the help of your Kaiser Aluminum Distributor.

L. M. Hobson of Portland, Oregon, designed the rack, named it the Dor-File, and began producing it by hand in 1947. A Kaiser Aluminum Distributor gave him technical advice, helped him improve fabrication methods. Today Mr. Hobson's Dor-File Manufacturing Company is turning out aluminum racks on a production line for nation-wide distribution, at the rate of 1,020,000 units per year!

If *you're* busy trying to perfect a new product—or improve an old one—may we suggest you consult your nearby Kaiser Aluminum Distributor.

He is eager to offer you the kind of service and engineering help that established his organization as one of the country's finest materials suppliers.

Take advantage of his service. Write down the name and telephone number of your nearest Kaiser Aluminum Distributor right now. You'll find him listed below.

Permanente Metals

PRODUCER OF

Kaiser Aluminum

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DETROIT, Michigan
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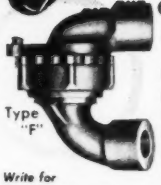

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A Bronze as Strong as Nickel Steel

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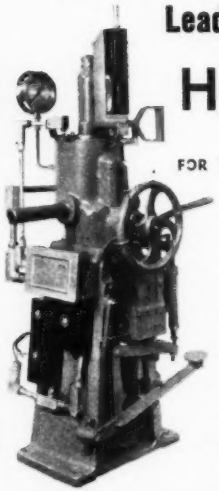
FOR BODY, STEM AND ROTOR



Yes, John Robertson, (an old and satisfied customer of ours) had to use a tough, strong, "leak-proof" alloy for these *Control Valves*,—so, like many valve makers, they specified *Hy-ten-sil Bronze*.

For many years, Robertson (one of the leading manufacturers of High Pressure Cable and Hose Lead Encasing Presses) has used *Hy-ten-sil* for various applications.

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"Which are the Best Alloys for MY Aluminum Castings?"

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Permite engineers and metallurgists through their wide knowledge of alloys for aluminum castings, have helped many manufacturers obtain the exact characteristics they need in their aluminum castings produced by Permite.

The advice of Permite engineers on your casting design in the development stage is available and highly desirable. Their recommendations often result in design modification that reduces the cost of the casting without altering its mechanical application or physical requirements.

The more than a quarter of a century of experience of the Permite organization, plus the unexcelled facilities of the modernly equipped Permite foundry, offer you definite advantages that may be translated into lower costs for your finished product.

Submit your castings requirements to Permite for recommendations and quotations without obligation.

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IF apparatus porcelain costs have you stymied . . . on products either existing or planned . . . bring your problem to Locke.

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FREQUENTLY Locke, in combination with your engineering department, can effect major cost reductions in apparatus porcelain by re-designing a piece so that it lends itself to modern low-cost manufacturing techniques.

SO, if you've got a problem in porcelain . . . either of a design or manufacturing nature . . . simple or complex, try us. The recommendations of our Ceramic Engineers may enable you to produce an existing piece for considerably less . . . or a new piece for much less than you expected to pay.

CONSULT your local Locke representative, or write direct. Address Department AP.

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Costly hood design

Less costly hood design

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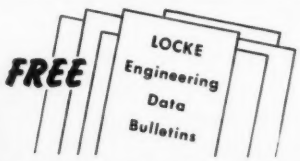

Contain plenty of money-saving hints on the design and manufacture of apparatus porcelain. Write for your free copy—today.

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Design Center for Industrial Ceramics

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you'll find them easier, faster if you...

...reach for your SWEET'S

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If Sweet's File for Product Designers is not available in your office, make request immediately for application form. Files are distributed FREE to qualified organizations and individuals.

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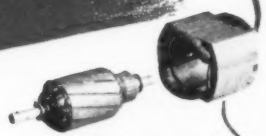
Special Engineering Provides the Exact Requirements For Your Product...

Lamb Electric MOTORS



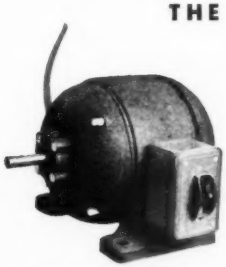
Series universal motor parts for portable business machines and many home appliances.

Fuel pump motor having space and weight saving design, suitable for many industrial uses.

Every Lamb Electric Motor is specially designed for the product or device it is to drive. This means that both electrical and mechanical characteristics are engineered for the exact requirements of the particular application, which often results in savings in space, weight and cost factor.

Special engineering in Lamb Electric Motors assures optimum product performance and efficient, long-life motor operation . . . another reason why more and more of America's finest products are being powered with Lamb Electric Motors.

THE LAMB ELECTRIC COMPANY
KENT, OHIO



Sturdy, heavy duty universal motor for sirens, grinder spindles, saw tables, and similar applications.

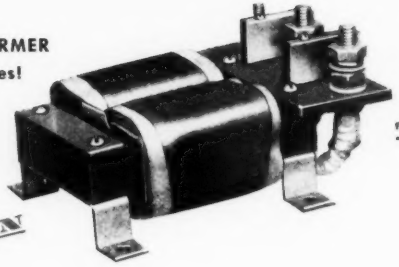
Light-weight universal motor with efficient spur gear speed reducer.

Rugged construction is a major factor in the reliability of this motor widely used in the field of mechanized equipment.

Lamb Electric

SPECIAL APPLICATION FRACTIONAL HORSEPOWER **MOTORS**

THE G. E. FLYWEIGHT TRANSFORMER
delivering a full kva from 52 ounces!



A DESIGN TO REMEMBER

an example of the application of

electrical insulating materials

made with

FIBERGLAS* *Yarns*

to help achieve **LIGHT WEIGHT** *and* **COMPACTNESS** *in electrical product design*

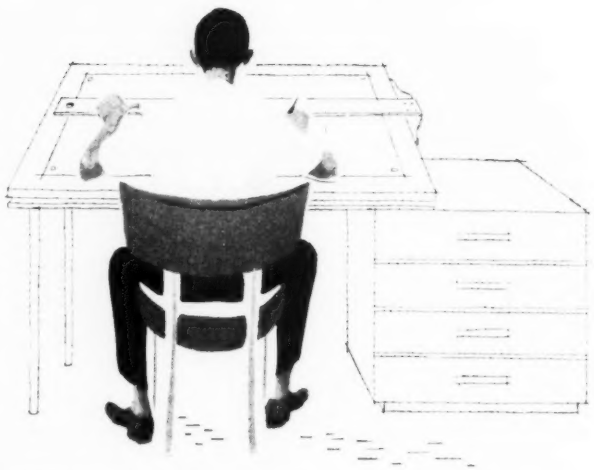
Insulating materials . . . *made of Fiberglas glass yarns* and silicone . . . contribute to the light weight and compactness of the amazing G. E. Flyweight transformer.

The Flyweight is the aircraft autotransformer which G. E. engineers designed smaller and lighter . . . *much smaller and approximately two-thirds lighter* . . . than conventional transformers . . . yet which delivers, ounce for ounce, 3 times the kva over a frequency range of 380 to 1,000 cycles!

That *is* a design to remember.

Specifically, glass and silicone insulating materials are used in this design as: *magnet wire insulation, lead wire insulation, layer insulation, laminate, sleeving, and tape. They are all made with space-saving, weight-reducing Fiberglas yarns.*

High thermal conductivity, plus high resistance to moisture, heat, corrosion, and rot are other basic properties of Fiberglas yarns. They, too, offer definite advantages when insulating materials are part of your product's design.



A new manual of Fiberglas-base insulating materials is just off the press. Send for a copy.

Owens-Corning Fiberglas Corporation, Textile Products Division, Department 807, 16 East 56 Street, N.Y. 22. In Canada Fiberglas Canada Ltd., Toronto, Ontario.

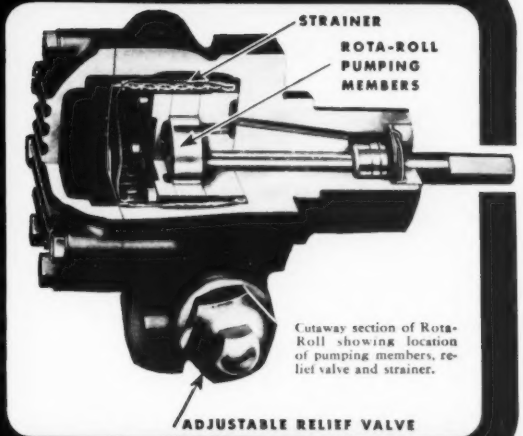
OWENS-CORNING FIBERGLAS *Yarns*

*Fiberglas is the registered trade-mark of Owens-Corning Fiberglas Corporation for a variety of products made of or with glass fibers.

Improve Your Product Without Increasing Cost...

With This Low Pressure, Low Cost Pumping Unit

It's small, compact and ideal for applications such as engine lubrication, compressor bearing lubrication, small capacity oil transfer, barber and dental chairs, small cylinder actuation and many others.



Cutaway section of Rota-Roll showing location of pumping members, relief valve and strainer.

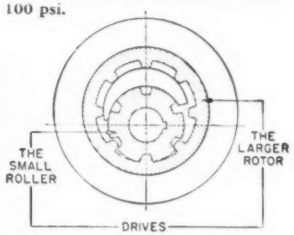
Complete With Pump, Relief Valve and Strainer

The Sundstrand Rota-Roll is more than a pump. It's a *pumping unit* complete with pump, relief valve and strainer. It's produced in large quantities on high production machinery — making its cost less than the cost of most pumps alone.

Available in 6 Sizes: From 11 G.P.H. to 40 G.P.H.

This pump has an adjustable relief valve which can be furnished in any of four pressure ranges of 20 to 40 psi, 40 to 80 psi, 80 to 150 psi, or 150 to 300 psi. The six capacities available range from 11 gph to 40 gph. These figures are based on a motor speed of 1725 rpm and 100 psi.

Check These 6 Advantages



1 ROTA-ROLL PRINCIPLE of pumping members promotes quiet operation, longer life because (see sketch) smaller roller is keyed to shaft and drives outer member at a speed 25% lower than motor speed.

2 QUIET OPERATION because ROTA-ROLL pumping members and efficient inlet port design reduces cavitation at the inlet port.

3 SMOOTH UNIFORM FLOW AT ALL PRESSURES because rotating roller and rotor are self-emptying, eliminating turbulence, and other interference with smooth, uniform flow of oil.

4 SMALL AND COMPACT (see illustration) will lend itself to and improve your product appearance.

5 HIGH OVERALL EFFICIENCY at maximum continuous duty pressure.

6 LOW COST OF THE ROTA-ROLL pumping unit is achieved through mass production manufacturing.

GET COMPLETE DATA FREE

Look into all of the features of this outstanding pumping unit. Complete description and mounting dimensions included. Ask for bulletin No. P-43.

SUNDSTRAND MACHINE TOOL CO. ROCKFORD, ILLINOIS U.S.A.

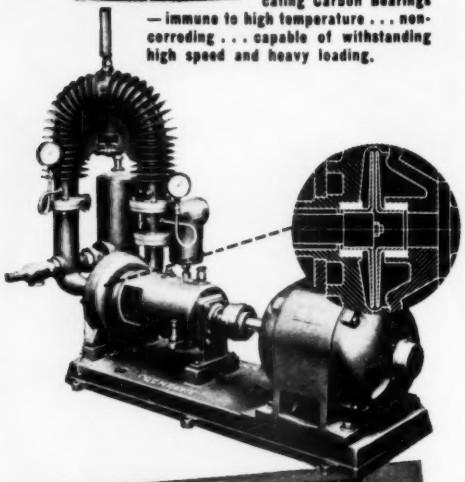
SUNDSTRAND HYDRAULIC DIVISION

2560 ELEVENTH STREET • ROCKFORD, ILLINOIS

FUEL UNITS • HYDRAULIC PUMPS • TRANSMISSIONS • FLUID MOTORS • VALVES and CONTROLS

PROBLEM: To supply bearings for high speed pump handling steam condensate at over 300°F, 300 PSI . . . to function without conventional lubrication . . . requiring no maintenance.

SOLUTION: Morganite Self-Lubricating Carbon Bearings — immune to high temperature . . . non-corroding . . . capable of withstanding high speed and heavy loading.



MORGANITE SELF-LUBRICATING CARBON BEARINGS

The fact that Morganite carbon bearings are standard equipment in this well-known condensate return pump is conclusive proof of performance in severe service. In this and many other applications, Morganite self-lubricating bearings, seals and rings have repeatedly demonstrated their ability to effect important economies by eliminating lubrication problems, reducing maintenance and permitting placement of bearings, seals, etc., in inaccessible locations.

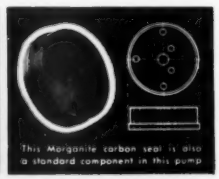
See our CATALOG in SWEET'S FILE for Product Designers

FOR DETAILS consult the Morganite Catalog in Sweets File for Product Designers; for engineering counsel or specific proposals, call in a Morganite sales engineer. There is no obligation.

REGISTERED TRADE MARK **Morganite** INCORPORATED

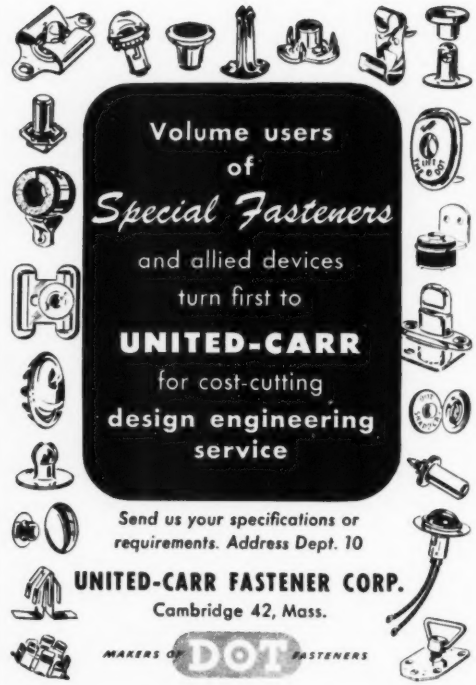
LONG ISLAND CITY 1, NEW YORK

Self-lubricating bearing used in centrifugal condensate pump above



This Morganite carbon seal is also a standard component in this pump

Manufacturers of Morganite Carbon Brushes for all motor and generator applications, and Morganite Carbon Piles



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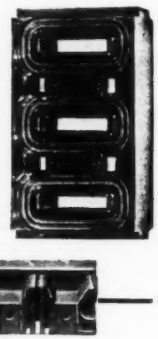
UNITED-CARR FASTENER CORP.
Cambridge 42, Mass.

MAKERS OF DOT FASTENERS

WHAT ARE YOUR INSULATOR SPECIFICATIONS?



Large in size? Small? Porcelain provides the widely desired qualities of high dielectric and physical strength, long service life, resistance to moisture, extremes of temperature and most acids. In addition, as the illustration shows, Universal Porcelain can be produced in intricate design to fit exacting specifications. A Universal engineer will be glad to work with you on your insulator problems. Phone, wire or write.

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Why an electrocardiograph tells it

All around you, men and women are enjoying life today, who might have been cut down in the prime of life. But, thanks to the electrocardiograph, their span of life has been extended. By charting any abnormality of the heart's beat-strength or functioning, the electrocardiograph supplies the vital facts from which the physician determines whether, where or how severely the heart or heart muscles have been injured. Then he prescribes the proper treatment.

THE ELECTROCARDIOGRAPH CAN'T HAVE "HEART TROUBLE"

The heart of many of these life-savers is a Telechron Timing Motor . . . *instantly, constantly synchronous.* Only such an accurate, trouble-free motor can be trusted to time the chart that tells the truth about heart trouble.

WHAT IS YOUR TIMING PROBLEM?

If you have a variable that must be controlled or recorded with split-second fidelity, a standard Telechron Motor, correctly applied, may be all you need. Ask a Telechron Application Engineer. He can give you the benefit of the broadest experience in the industry. The earlier in your planning you call him, the better are your chances of saving time, trouble and money. In the meanwhile, fill in and mail the coupon below for complete data on Telechron Synchronous Motors. TELECHRON INC., A GENERAL ELECTRIC AFFILIATE.

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Please send me information on sizes and types of Telechron Synchronous Motors. My possible application is:

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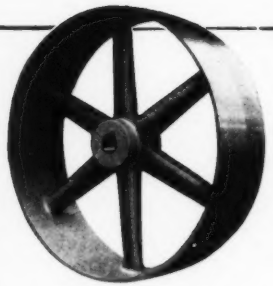
High test cast iron pulleys in all sizes and types

Completely split pulley



Single arm solid pulley

JONES cast iron pulleys are true running — they permit higher speeds — no bushings and they can't fall apart — they don't rattle and they look better on most machines.

These pulleys are machine molded, poured of high test cast iron, and are accurately finished and balanced. Multiple piece pulleys, rubber covered pulleys and flywheels can be furnished.

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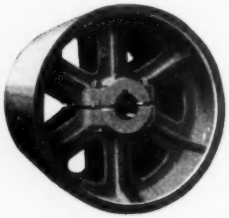
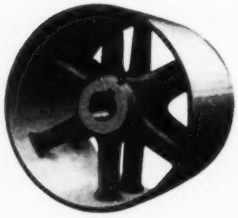


Extra heavy conveyor pulley



Double arm pulley

Jones

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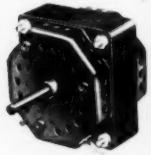
Mass production for mass markets —that's why Alliance is the best source for low cost, small load motors.

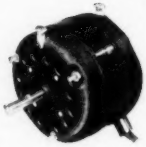
Alliance Motors have these outstanding advantages:

Low operating cost — **Cool running**
Low induced hum — **Flexible power range**
Low magnetic field — **Slower controlled speeds**

Alliance builds 4-pole and 6-pole shaded pole induction motors with speeds from 500 to 1550 rpm and from 1/100 h.p. up to 1/25th h.p. Smaller 2-pole shaded pole motors will supply as little as 1/400 h.p.

MODEL P
4-pole shaded pole motor. Approx. 1/30 h.p. 1550 r.p.m.



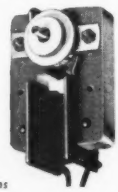


MODEL A
6-pole shaded pole motor. Approx. 1/30 h.p. 500 to 1050 r.p.m.

MODEL MS
2-pole shaded pole motor — full load h.p. .0021. Full load 2800 r.p.m.

Typical Fan Motor Uses

Air Circulators
Room Heaters
Exhaust Fans
Coolers
Air Conditioners
Unit Heaters
Hair Dryers
Controls



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This tiny switch is doing a giant job. It is long-lived . . . 50 million cycles is not an exception. It is adaptable . . . crowded spaces are no bugaboo. It is economical . . . costs little to begin with and little to engineer into your product. Quality and economy-minded design engineers have already used it in coin vending machines, record players, automatic controllers, sign flashers, business machines and sterile toilet seats . . . and new applications are being developed every day.

The "mighty midget" is available in SPST and SPDT . . . with plain or platinum tipped electrodes . . . maximum tilting angles of 5° and 12°. Investigate these qualifications . . . today . . . your local Brown engineer is as near as your phone.

Write for your copy of Catalog 1343 . . . for full description and specifications on the complete line of Honeywell Mercury Switches.

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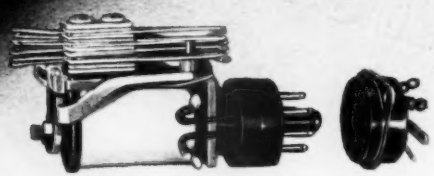
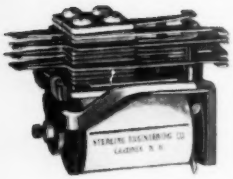
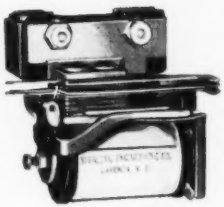
Industrial Relays by Sterling







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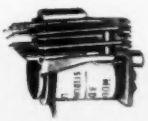
Adaptability, convenience and dependability are some of the features which explain the general acceptance of STERLING RELAYS in industry.

STERLING WILL ENGINEER AND DESIGN RELAYS FOR YOUR PARTICULAR REQUIREMENTS.

Types KS midget and GS relays illustrated.

Write today for your copy of STERLING'S new Bulletin 110 on RELAYS FOR INDUSTRY.



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THE GOOD RIGHT HAND OF INDUSTRY

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NEW Air Compressor Line *Since the War*

It's the Worthington Balanced Angle—the really modern-looking vertical air compressor that is as up-to-date *inside* as out!

See how this machine has been redesigned from the bottom up to give you everything we know you want in an air compressor—

Improved Appearance. The clean sweep of the base, the even balance of the cylinders, the compact arrangement of intercooler and clean sturdy feet make it a credit to *your* equipment.

Smoother Performance. The V-type cylinder arrangement gives better running balance and faster cooling.

Higher Efficiency. The isolated cylinders have 35% more heat radiating surface than in-line type; the aluminum heads release heat faster than cast-iron; and the high-speed fan throws 6 times as much air across the cylinders.

Less Maintenance. The valves are exclusive Worthington Feather* Valves; lubrication is controlled; bearings are famous Timken roller bearings, including oversize main bearings.

Longer Life. The pistons in each stage, though different in size, *weigh alike*, reducing vibration; crankshaft is drop-forged steel with integral counterweights; bearing pressures and piston speed are low.

The Worthington line of Vertical Air Compressors includes single and two-stage models, base or tank-mounted, ½ to 15 hp.

*Reg. U. S. Pat. Off.

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PUMP AND COMPRESSOR MERCHANDISING DIVISION
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JUST PRINTED

Two bulletins showing how
NEW G-E MOTOR EXCHANGE PLAN
cuts machine down time

Get the story of the new time and money saving General Electric exchange plan for Tri-Clad integral-hp motors! It's an extension of the highly successful G-E fractional-hp motor exchange plan and covers most popular types of Tri-Clad open dripproof motors—one to five hp. Bulletin GEA-5189 is for motor users; Bulletin GEA-5180 is for machinery manufacturers. Write on your letterhead FOR FREE COPY: *Apparatus Department, General Electric Company, Schenectady 5, N. Y.*

Look for this extra on the motors you buy; it means lower maintenance costs, less time lost for motor replacement.

GENERAL ELECTRIC

106-3

HEAT DISSIPATION
No longer a Problem!

X-Ray Corporation of America standard x-ray showing the Eastern Model 2-XR Heat Transfer Unit in operating position.

Eastern Model 2-XR Heat Transfer Units successfully dissipate the heat generated by x-ray tubes in standard X-Ray machines built by the X-Ray Manufacturing Corporation of America, New York City. This insures uniform temperature control and longer tube life. The unit eliminates the inconvenience and expense of using tap water as the tube cooling system.

If you have a problem that can be solved by using equipment that contains a pump as an integral unit, why not consult Eastern engineers?

Eastern pumps require no introduction. Their compact design and remarkable performance make them ideally adaptable where space and portability are factors.

They incorporate the finest of workmanship and material. Consultations on special pump problems entail no obligation. Write:

Eastern Model D-11 heavy duty centrifugal pump. Size: 10" x 5½" x 5". Weight: 18 lbs. Power 1/8 h.p. heavy duty induction motor. Available in 110 or 220 volts a.c. Maximum output 8 g.p.m. at zero pressure. Maximum pressure 14.5 lbs. p.s.i. at shut off.

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The Right Switches... at the Right Price...

to modernize your product and to enhance its "saleability"

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NEW!

Two slide switches rated 1 ampere at 125 volts DC

3 amperes at 125 volts AC

These sturdy little switches are ideal for appliances, toys and electrical equipment requiring 3-ampere switch contact carrying capacity. Both are Underwriters approved. Write for SS-26 Switch Bulletin.

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Dozens of Contact Arrangements

Inexpensive types are available for practically any switching requirement and at prices that will please you. Samples to specifications on request to quantity users. Write for Stackpole Switch Bulletin RC7C.

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STACKPOLE

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Draftsman: "You old reprobate, you spoiled a two hundred-dollar drawing! Look how brittle and opaque it is!"

Father Time: "Yes, but you drew it on tracing paper — when you should have used Arkwright Tracing Cloth!"

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The Big Six Reasons Why Arkwright Tracing Cloths Excel

1. Erasures re-ink without feathering.
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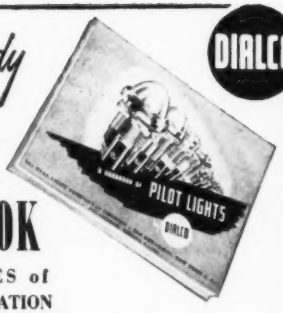

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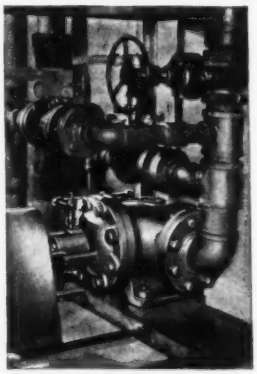

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This quiet, reliable, pulsation-free, vibrationless pump is just the thing for hydraulic elevator operation – or any other service where noise is a nuisance and reliability is essential.

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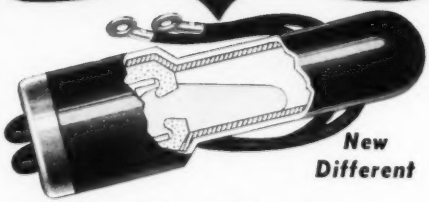

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5 new models

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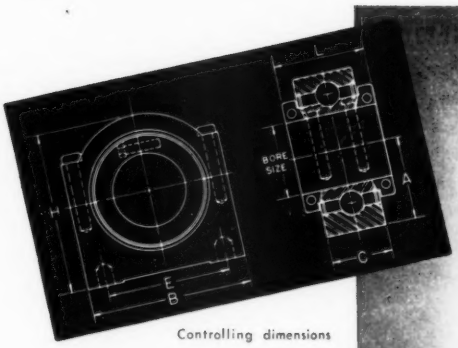
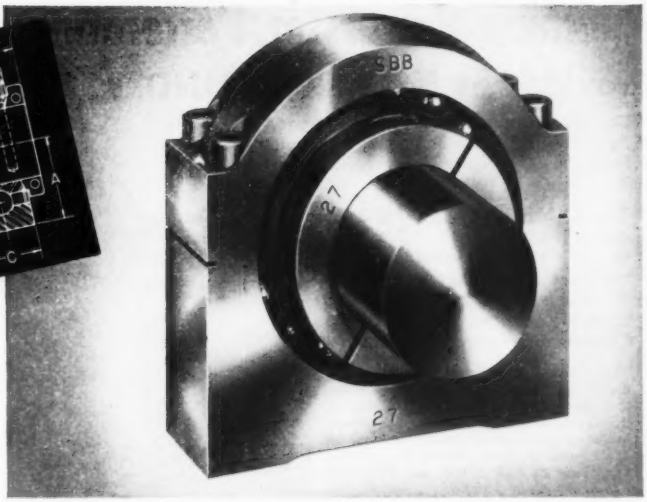
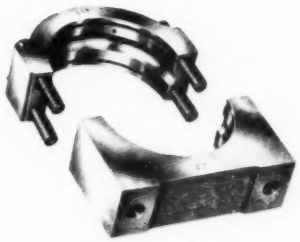


Controlling dimensions for typical unit. See chart below for actual dimensions.



Split PILLOW BLOCK

A NEW and BETTER PILLOW BLOCK



OUTER RACE

INNER RACE

In sizes from 15/16" to 3-15/16" dia. shafts with "split" or divisable inner and outer race.

It has these features —

Both the inner race and the outer are "split". This permits installation in places where the solid race bearing cannot be installed.

The outer race is also the pillow block, made from a forging of bearing steel, into which the ball race is ground to close tolerances.

Center height is held to a close tolerance and can be easily increased by means of adapter plates. Two screw holes in the base of the outer race of housing secure the unit to its related part.

The seal rides into a free fitting groove in the inner race and is retained by a groove in the outer race—a highly effective labyrinth type of seal.

There is a large space for lubricant with a grease fitting for relubrication.

Because of the split feature, a greater number of balls can be assembled in the bearing than is possible with solid race construction.

It is designed as either rigid or self-aligning type with a synthetic retainer. The ball pockets are drilled. No rivets—no crimping.

The inner race is positioned by drawing up on four screws which locks the inner race to the shaft.

Dimensions of Split Pillow Block for $1\frac{11}{16}$" dia. shaft

Bore Size	A	B	C	L	H	E	No. Balls	Size Balls	Base Threads
$1\frac{11}{16}$"	$2\frac{1}{8}$"	$4\frac{1}{8}$"	$1\frac{3}{8}$"	$2\frac{1}{4}$"	$4\frac{3}{16}$"	$3\frac{1}{4}$"	17	$\frac{1}{2}$"	$\frac{7}{16}$"

PRINT WITH COMPLETE DATA MAY BE OBTAINED FROM—

·DIVISIBLE RACE BEARINGS·

SPLIT BALLBEARING CORPORATION

LEBANON, NEW HAMPSHIRE. U. S. A.

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Punching Power for Perforating Press

Provided by NOPAK CYLINDERS!

This unique press was specially designed and built by Verdin, Kappes & Verdin, Cincinnati, O., for high-speed, precision perforating of matching elbow blanks.

Two 3" Model "C" NOPAK Hydraulic Cylinders, controlled by one foot valve, supply ample power to perforate sheet steel, up to 24 gauge ● Maximum speed, 100 — 1" strokes per minute ● Maximum capacity, eleven 9/64" holes ● Operating pressure, 400 P.S.I.

This press has reduced spoilage substantially, has resulted in greater accuracy, has increased operating safety by eliminating the flywheel. Chances are that your standard or special machines can be designed for or converted to air or hydraulic operation by employing NOPAK Valves and Cylinders.

Duplex Hydraulic Perforating Press, of special design, uses 2 NOPAK Model "C" Hydraulic Cylinders.

NOPAK Model "C" Cylinder, either Air or Hydraulic, is designed for flat base mounting and vertical pushing power, either up-or-down-stroke.

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Large capacity devoted exclusively to the building of Machines, Assemblies and Parts for other concerns. Estimates furnished promptly upon receipt of prints or letter of inquiry. Bulletin E-200 lists our machine equipment.
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Screens used in grain testing require an extreme accuracy of diameter for round holes and for dimensions of slotted perforations. Here H & K. screens test only ± .0005 variation in diameter of all the holes per screen. Such accuracy is a part of everyday H & K production.
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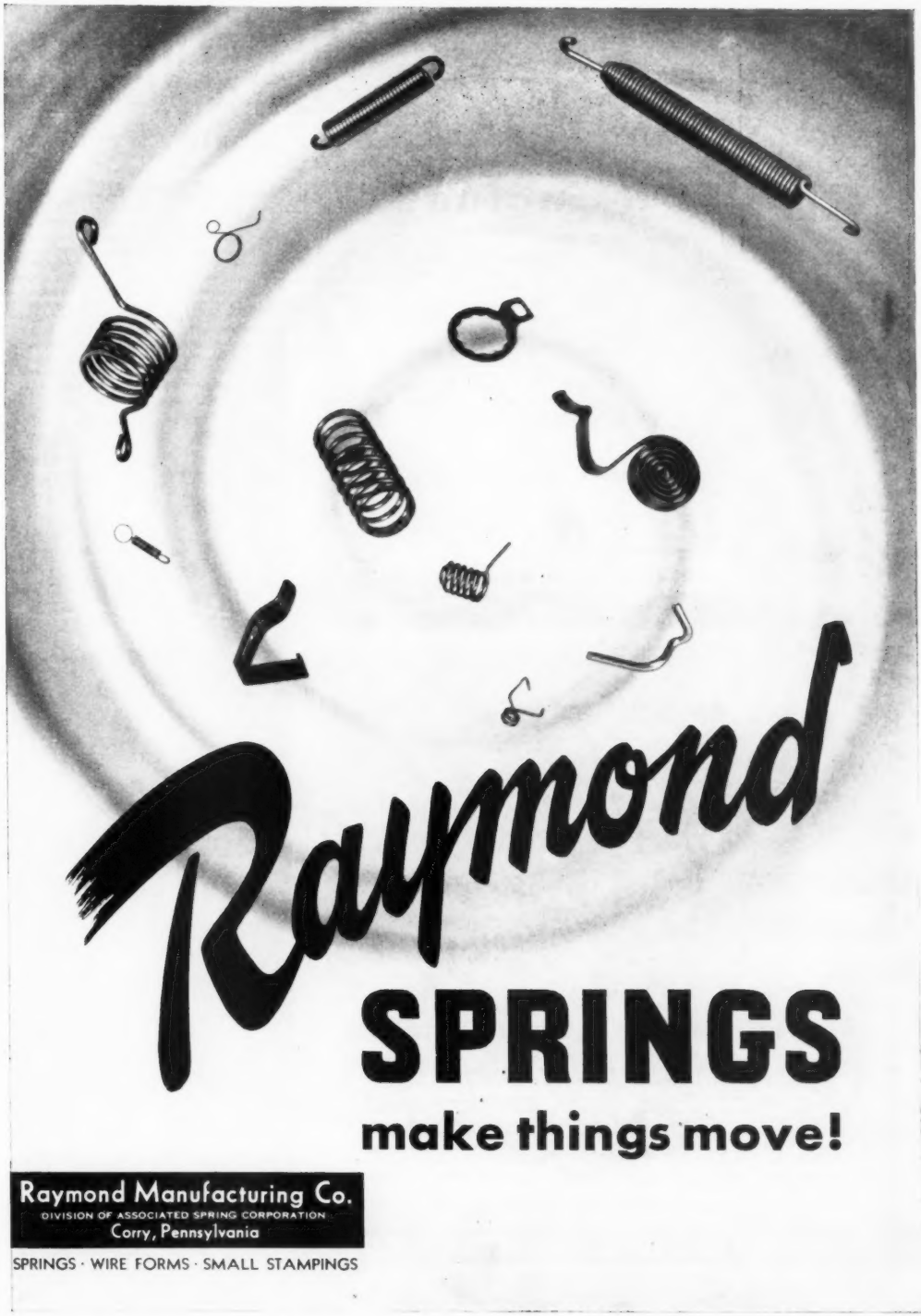
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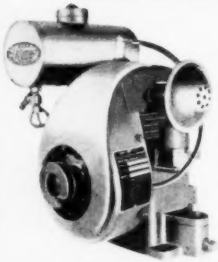

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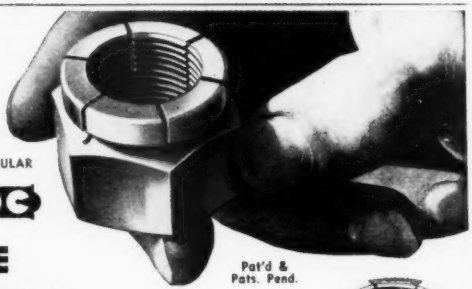

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FLEXLOC

ONE-PIECE SELF-LOCKING NUTS

Pat'd & Pats. Pend.

THIN

. . . WON'T SHAKE LOOSE . . . REDUCE MAINTENANCE

Invariably, when nuts loosen, they cause shutdowns, loss of production, and bad tempers all around. All this can readily be eliminated by installing the one-piece, self-locking "FLEXLOC", because *it positively will not shake loose* and positively cuts cost of maintenance.

The all-metal, one-piece resilient "FLEXLOC" is becoming increasingly popular, because it is processed to have an exceptionally uniform torque and, because it packs a stop, lock and plain nut all in one. "FLEXLOC" accommodates itself to a wide range of thread tolerances and can be used over and over again without losing much of its torque. And, being a stop nut, it stays locked in any position on a threaded member. It is not affected by temperatures commonly met within the Industrial Field of Mechanical Engineering.

Available in "thin" and "regular" types—in sizes from #6 to 2" in diameter—in NC and NF thread series. Write for your copy of the "FLEXLOC" Catalog.

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When designing new products remember Littleford can fabricate plain or alloy plate and sheet metal into any size or shape Weldment to fit your needs. Littleford Weldments for 68 years have played a vital part in many a product, such units as Bases, Guards, Pans, Louver Covers, or Special Parts have been produced at low cost by precision work and know how. Experience in bending, forming, shearing and welding is assurance of the high quality Weldments. Send blue prints to Littleford for estimates.

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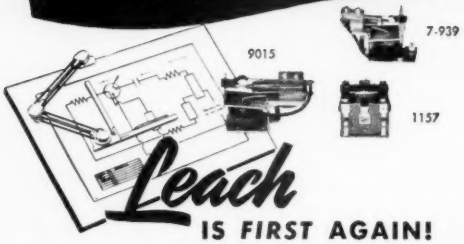
ALL *Peerless Motors* ARE "PEERLESS REGISTERED"

Off the Drafting Board... *INTO YOUR CIRCUIT!*



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Leach is *first* again with newly modified *Relays* designed, engineered and constructed to meet *your* specific requirements. For easier installation, better performance and longer life.

No. 7-939 is a newly modified motor starting relay. No. 1157 is an industrial type for handling 12½ amperes. No. 9015 is a motor starting relay designed to handle motor loads up to 3 horsepower.

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MANY INDUSTRIAL ROLL PROBLEMS are solved by using

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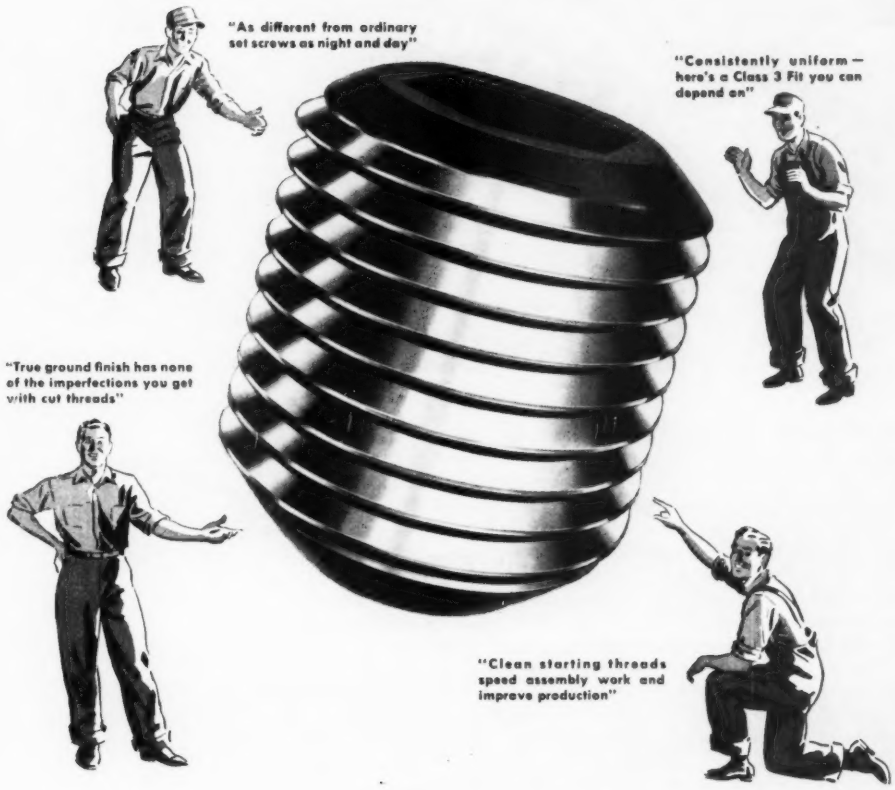
Parker-Kalon GROUND THREAD Socket Set Screws are The TALK of the SHOP!


"As different from ordinary set screws as night and day"
"Consistently uniform — here's a Class 3 Fit you can depend on"
"True ground finish has none of the imperfections you get with cut threads"
"Clean starting threads speed assembly work and improve production"

Compare! Write for Samples!

See why P-K Ground Thread Socket Set Screws speed assemblies, improve strength and safety. Thread grinding, once reserved for screws used in the finest precision equipment, now gives Parker-Kalon Socket Set Screws the accurate finish and faultless contour that mean faster assembly and more sales for your products. Write for samples today.

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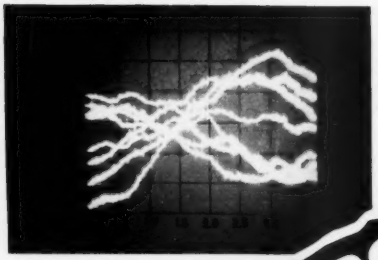
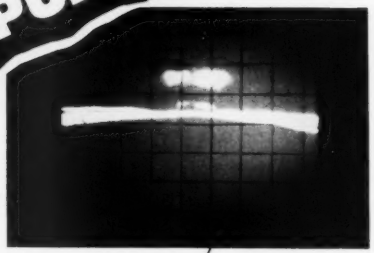


BEFORE INSTALLATION OF ACCUMULATOR
Horizontal graduations equal 50 psi and full sweep equals 0.3 seconds. Without accumulator the maximum pressure swing of the surging fluid is 350 psi.

HOW TO IRON OUT PUMP PULSATIONS



AFTER INSTALLATION OF ACCUMULATOR
Same installation with accumulator in system, the maximum pressure swing was reduced to 20 psi.

Pressure surges and pump pulsations are the two most common causes of pipe lines and hydraulic system failures. Surges and pulsations, however, can be greatly minimized or eliminated by installing a Greer Accumulator in the system. A simple "T" connection is all that is necessary to install it in any existing or newly designed circuit.

The "Before" and "After" photographs above give vivid proof of the effect of accumulators in hydraulic systems. A hydrauliscope and camera attachment were used to photograph the surges and pulsations of an actual pumping circuit. The "Before" picture shows the high degree of pulsations in the line not using an accumulator. The "After" picture shows how these surges and pulsations were effectively ironed out and virtually eliminated by the use of an accumulator.

Similar tests can be performed in your own system to demonstrate the effectiveness of a Greer Accumulator.

A request for further information on your company letterhead will bring an immediate reply. Write today!

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EXTREMELY DURABLE
CONSTANT CO-EFFICIENT OF FRICTION OPERATES DRY — OR *SUBMERGED IN WATER, GASOLINE OR CORROSIVE LIQUIDS*
APPLICABLE OVER A WIDE TEMPERATURE RANGE — *even where oil solidifies or carbonizes* EXCELLENT AS A CURRENT-CARRYING BEARING.

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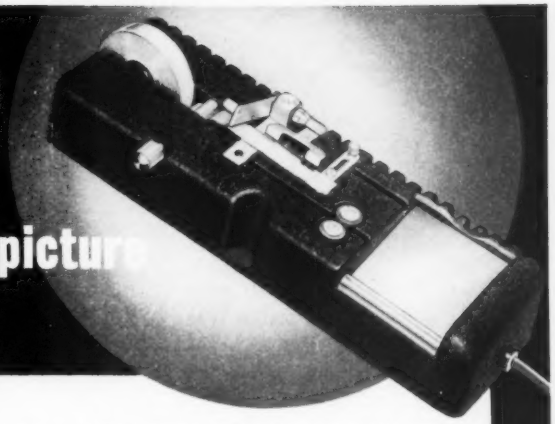
DIE CASTING
brightens the whole production picture



CASE HISTORIES FROM MT. VERNON FILES

Take a look at die casting, and you get a new slant on your whole production picture. For die casting means *speed* and *economy* . . . and improved products to boot!

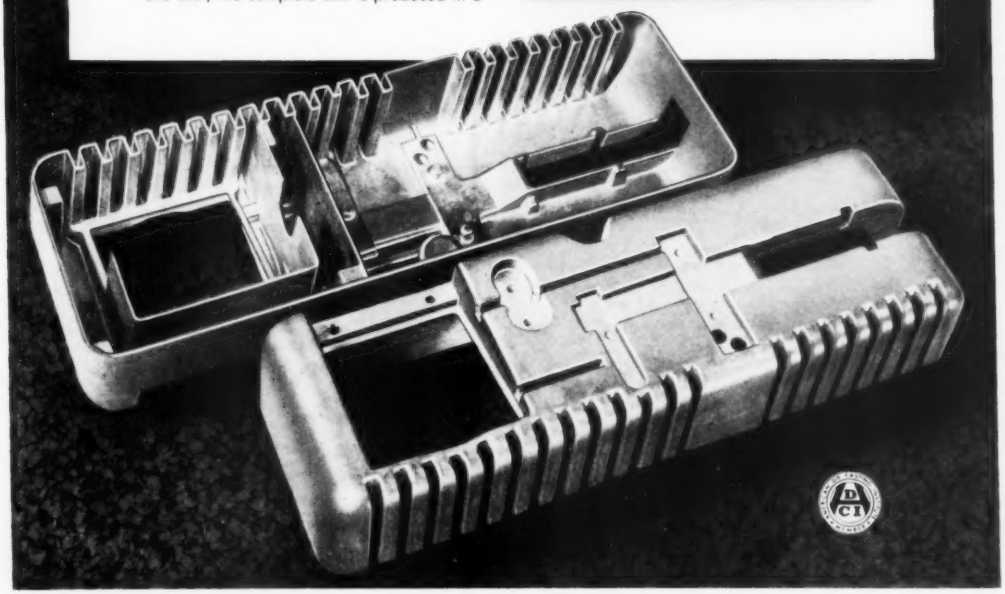
Here, for example, is the Leitz "Bindomat", an efficient device for binding photo transparencies, to make slides. Its design calls for:

(a) cavity to receive tape roll;
(b) indents to accommodate tape spool axle, tape feed spindle knob, and C clamp (for clamping to table);
(c) channels for tape feed, cutting knife mount, and tape locating clip;
(d) aperture for viewing transparencies;
(e) slots for guiding and holding slides while binding;
(f) wells for 2 binding rollers;
(g) rack for 20 finished slides;
(h) reinforcing sections and members underneath.

Die-cast, the complete unit is produced in a single operation with such accuracy that machining is reduced to a negligible minimum.

That's how we, at Mount Vernon, help manufacturers eliminate *time waste* and *material waste*—increase output, lower costs. So whether your product be small or large, simple or complex, consult with us . . . find out how our skills and facilities can brighten your entire production picture.

MT. VERNON
DIE CASTING CORP.
MT VERNON, NEW YORK



Here—

unusual springs are the usual thing

Combinations or Assemblies as well as intricately formed flat and coiled springs

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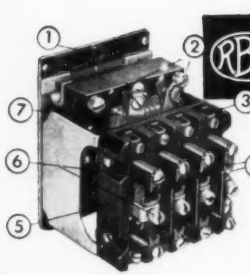
COOK PLANT • ANN ARBOR, MICHIGAN



RBM INDUSTRIAL CONTACTORS

2 TO 8 POLE
600 VOLT A. C.
10—15 AMPERE SIZES
REVERSING—NON-REVERSING TYPES
INTERCHANGEABLE CONTACTS

1. Heavy steel base.
2. Coil readily replaced by removing 2 heavy screws holding E-shaped magnet frame.
3. Accessible solderless type terminals are conveniently located. All line terminals at top; load terminals at bottom.
4. Any pole can be changed from normally open to normally closed, or vice-versa, without additional parts.
5. Melamine stationary contact block and movable contact carrier.
6. Stationary and movable contacts can be readily replaced with use of screw driver only and without removing wiring.
7. Vacuum impregnated magnet coil designed for continuous 50/60 cycle service.

For descriptive bulletin No. 600 write Dept. E-7

R-B-M DIV., ESSEX WIRE CORP.
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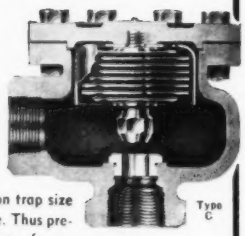
RBM

MANUAL AND MAGNETIC ELECTRIC CONTROLS
FOR AUTOMOTIVE, INDUSTRIAL, COMMUNICATION AND ELECTRONIC USE

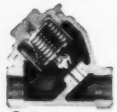
Nicholson Steam Traps

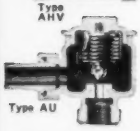
STOP BACK-UP of CONDENSATE

Operate on Lowest Temperature Differential



Repeated comparative tests by large users of traps show that Nicholson traps operate on lowest temperature differential: 5° to 15°, depending on trap size and pressure. Thus prevent back-up of condensate and keep equipment full of live steam. Installations have increased production of cooking kettles, for example, as much as 30%. Widely specified for preventing damage to thin gauges. Eliminate "cold blow" in unit heaters. Size ¼" to 2"; press. to 225 lbs. BULLETIN 1047.





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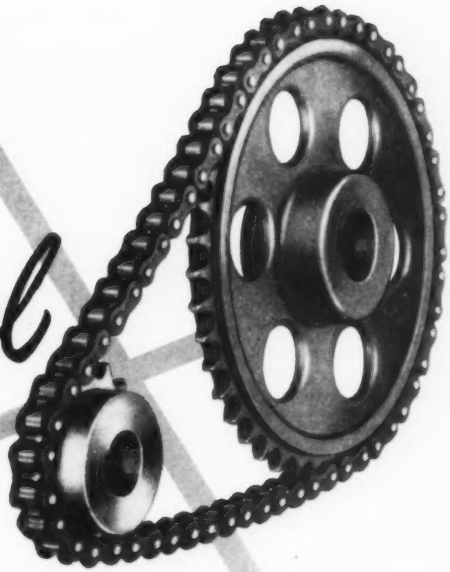

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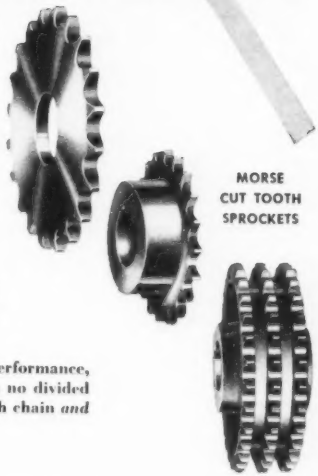

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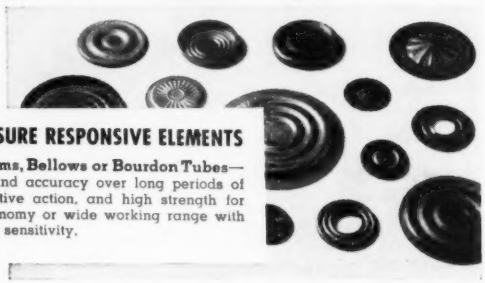

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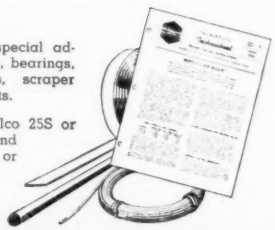

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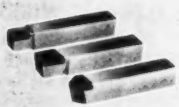

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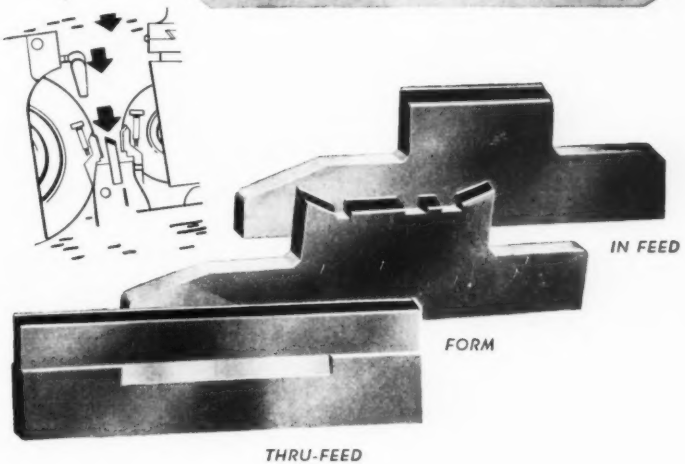

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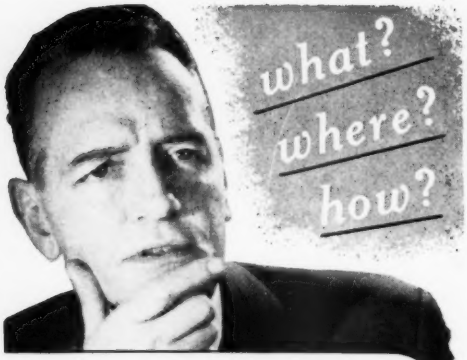

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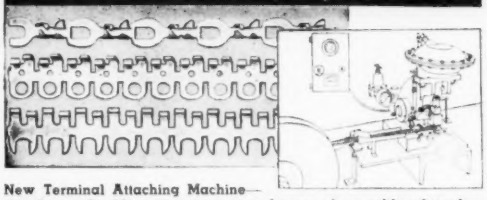

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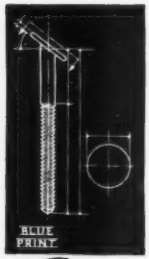

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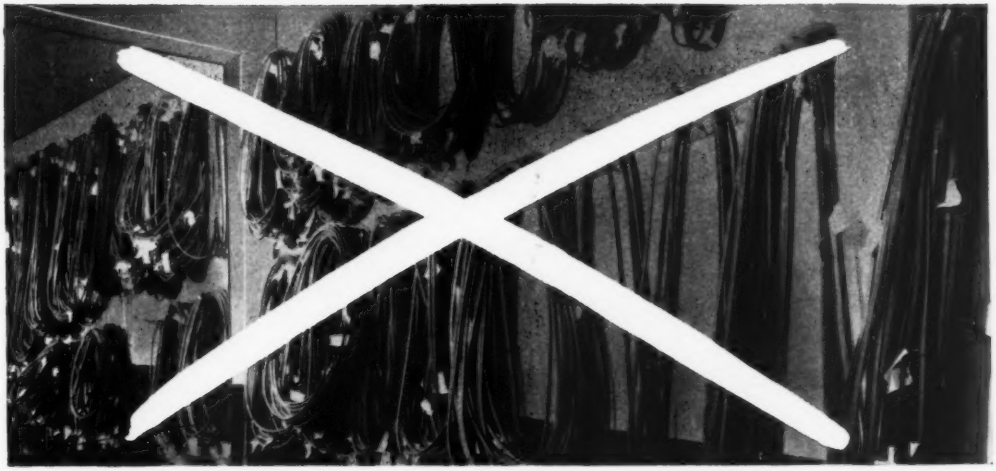
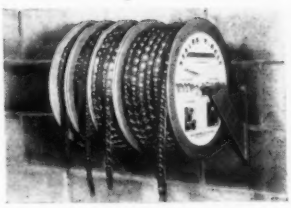
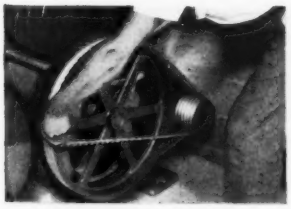


Here's how to cut your v-belt costs

You can replace up to 316 sizes of endless v-belts with just 4 reels of Veelos



From these four reels of Veelos you can make up 316 sizes of O, A, B and C section endless v-belts.



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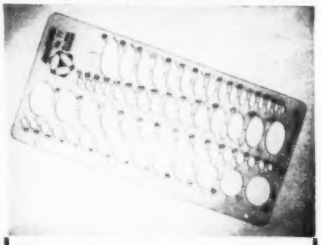

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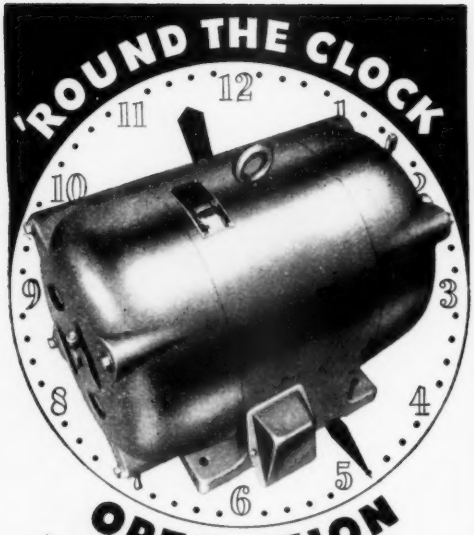

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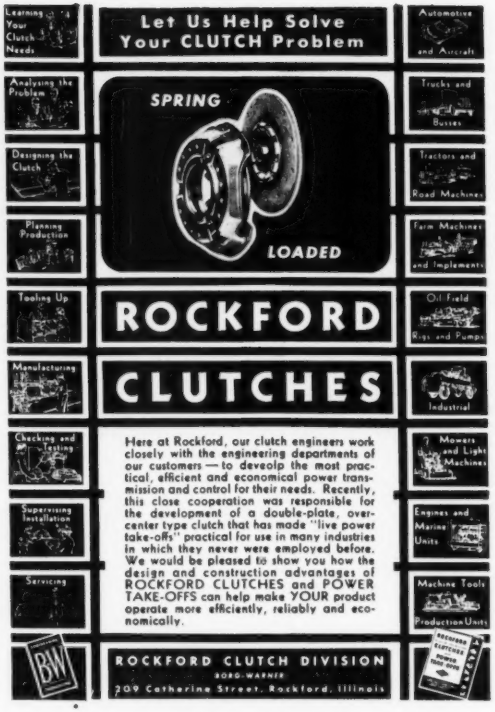
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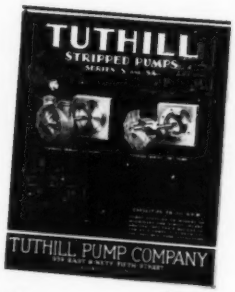

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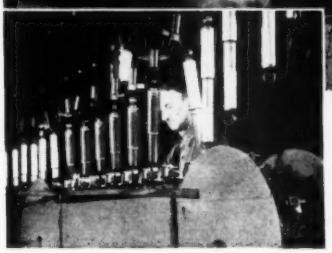
J&L STEEL



(*Above*) Multiple spindle broaching machine at the Houde Engineering Division of Houdaille-Hershey Corporation that machines the inside diameter of J&L ELECTRICWELD Tubing to 1/1000" tolerance.

(*Left*) Aeroplane-type shock absorbers on the production line at the Houde Engineering Division, Houdaille-Hershey Corporation, Buffalo, N. Y.

When production runs into thousands of units daily, every possible saving in material and labor costs in each shock absorber is vital to efficient manufacturing. Houdaille-Hershey Corporation, Buffalo, New York, reduced manufacturing costs when it changed from more expensive cold-drawn tubing to J&L *free-machining* ELECTRICWELD Tubing for the main cylinder of precision-built hydraulic shock absorbers.

This special J&L tubing is made from *resulphurized, open-hearth steel.* The resulphurizing imparts the desired free-machining quality required by Houdaille-Hershey for broaching the interior surface of the cylinders with uniform precision to a tolerance of 1/1000 of an inch.

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MILWAUKEE 14 WISCONSIN

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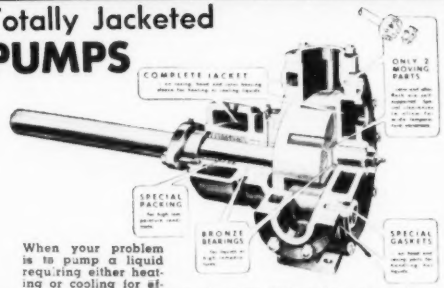
Totally Jacketed

PUMPS



When your problem is to pump a liquid requiring either heating or cooling for efficient handling, look to the new Viking line of totally jacketed pumps.

Complete jackets surround the pump casing, head and stuffing box. Pump available with any combination of jackets.

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SMALL BUT POWERFUL! Well over four hundred pounds of output force is at your command to PUSH . . . PULL . . . LIFT . . . PRESS . . . CLAMP . . . GRIP . . . or SQUEEZE with this small 2½" cylinder connected to ordinary shop air supply at 90 p.s.i. Air consumption approximately two hundredths of a cubic foot per inch of stroke.

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"AUTOMATION" is an interest-rousing new term that describes some of the many ways in which pneumatic cylinders are being used to actuate and power automatic work-saving devices. Hannifin is playing an important part in this development by supplying cylinders that are *right for the job* and engineering *know-how* second to none when it comes to applying cylinders to the job.

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● 48 pages of information about Hannifin Pneumatic Cylinders. Complete range of sizes from 1" to 12". Six basic mounting styles, plus combination and double-end rod styles. Any length stroke, with or without cushions. Write for a copy of Hannifin Bulletin No. 210.

Chace Thermostatic Bimetal safeguards users of the Sonner Gas Conversion Burner in event of pilot flame failure.

An actuating element of Chace No. 2400 Thermostatic Bimetal is the heart of the Sonner Type R Automatic Pilot; under an adequate pilot flame which impinges upon the bimetal element, an electrical contact is maintained, controlling the main gas valve. Should pilot flame fail, the bimetal cooling immediately bends, opening the electrical contact, causing the main gas valve to close. With pilot flame re-established, the heated bimetal bends back, closing the electrical contact, allowing the main valve to open in response to the automatic temperature control.

The high thermal deflection rate of Chace No. 2400 Bimetal makes it ideal for this application—and the ideal bimetal for *your* problems in temperature indication or control can be found in the W. M. Chace Company line of 29 different bimetals. All are available in strips, finished pieces or subassemblies. Consult Chace engineers for assistance in determining the correct bimetal actuating element for *your* product.

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Sizes: One inch to 30 Mesh
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Metals: Steel, Copper, Brass, Bronze, Aluminum, Stainless Steel, etc.
Gauge: 14 to 39 and special
Finish: Tinned, galvanized, painted or plain steel.
Widths: 24"-48" standard; also narrower or wider, and slit or cut to size.

Inquiries about special grades and special applications are welcomed. Cortland Brand Industrial Wire Cloth can help you build your product better.

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WICKWIRE BROTHERS, INC., Cortland, N. Y.

At Last! Quick-Disconnect Hose Coupling Guaranteed - - - Positively Leak-Proof!

On "Impossible Jobs" or in hard-to-reach places where ordinary Quick-Disconnect Couplings fail — WIGGINS Inst-O-Matics have made sensational records — yet cost no more than old fashioned

If you have a hose line that fails to hold under pressure—whether water, air, gas, fluids, hydraulic—we guaranteed that a Wiggins Inst-O-Matic Quick-Disconnect Coupling will hold the pressure (and increase flow)! You'll get operation and maintenance savings up to 80% over old-fashioned couplings.

Big firms delighted! We asked for the toughest coupling jobs in these companies—and now we're getting repeat orders! . . . Ford, Chrysler, General Electric, Westinghouse, Inland Steel, General Petroleum, Continental Can, Shell Chemical, Union Pacific Railroad—and scores of others.

Let Us Show You! Wherever you are now using old-fashioned screw-on couplings or any other quick coupling, let us show you how much you can save with Wiggins Inst-O-Matic Couplings, now made in sizes ⅛" to 2½", open and self-sealing, in a variety of metals with Wiggins Quick-Disconnect Couplings. *To Equipment Manufacturers:* Wiggins Inst-O-Matic Couplings are now widely used in special applications by agricultural, automotive, aircraft, heavy industries and on miscellaneous equipment, where performance, flexibility and safety are vital. Address confidential inquiries to Special Equipment Division, E. B. Wiggins Oil Tool Co., Inc., Dept. IEN, 3424 East Olympic Blvd., Los Angeles 23, California. Representatives in principal cities.

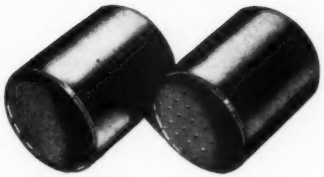
¼" Air Hose Coupling

JOHNSON BRONZE
SLEEVE BEARING DATA

Bearing TYPES

JOHNSON BRONZE
SLEEVE BEARING DATA

Sheet Metal Bearings-1



SHEET METAL BEARINGS, sometimes referred to as either thin wall, rolled-up, slip-in, split or laminated, are available in four different types, i.e.:

1. Bronze sheet metal
2. Bronze-on-steel
3. Steel and lead babbitt
4. Steel and tin babbitt

They are comparatively low in price . . . particularly when there is quantity of a size . . . yet high in efficiency, possessing many unusual bearing qualities. With the exception of certain automotive replacement parts, sheet metal bearings are not stock items but are made to specifications determined by the requirements of the application.

Bronze Sheet Metal

The necessity for ductility limits bronze sheet metal bearings to two alloys, containing not more than 4% lead and 4% tin. Higher percentages of these metals would render the material too hard for rolling. As listed below, Johnson's alloy No. 44 is the highest grade and comes closest to plastic bronze. Due to the limitations of the elemental constituents these two alloys have a higher coefficient of friction and not quite as great load carrying capacity as cast bronze. However, the rolling operation imparts a dense structure to the metal which results in excellent resistance to pounding and to shock. The degree of hardness can be furnished as specified.

Bearings made of number 40 alloy should be burnished in place as the metal has low machining qualities; however, number 44 alloy can be burnished, bored or reamed in assembly.

The most common wall thicknesses are 1/32" and 1/16", with a variation of .005" plus or minus from the nominal size. One of the advantages of limiting the wall thickness to 1/16" is that the bearing can be easily seated in place by burnishing. Oil holes, slots or grooves are easily added during the fabricating process.

Bronze Sheet Metal bearings are excellent for applications where motion is comparatively low and impact is the main factor. They are also ideal and most economical for use where atmospheric or gaseous conditions may corrode cast iron or steel.

	Johnson Alloy No. 40 S.A.E. 795	Johnson Alloy No. 44 S.A.E. 791
COPPER	90.0%	86/90%
TIN	0.5%	3.0/4.5%
LEAD		3.5/4.5%
ZINC	9.5%	3.5/5.0%
HARDNESS ROCKWELL B 65-71—1/16 Ball 100 KG. LOAD		

Burnishing is desirable in all cases when possible for it imparts a dense smooth bearing surface, seats the bearing in place properly and renders the bore uniform. The common stock allowance for burnishing is .002" to .004".

If bearings are to be used in cast iron housings, or other types which may not be strong enough to permit a burnishing operation, it is recommended that a material be used possessing good reaming properties. Sometimes it is necessary, due to design of application, to ream two or more bushings in line. Reaming stock allowance should be about .006" to .009".

In cases where any doubt exists regarding the best method of sizing sheet metal bearings in assembly, it is advisable to submit complete data to our engineers. We will draw on our vast experience and give you a straight-forward answer for your particular problem without obligation. In some cases we often find it advisable to submit samples for test application in order to be absolutely certain that the correct solution has been found before fabrication of the complete order.

Points to remember when ordering

1. Housing hole size and housing material.
2. I.D. required after finishing in assembly.
3. Method of finishing I.D.
4. Shaft diameter and tolerance.
5. Special features such as grooves and holes should be specified.

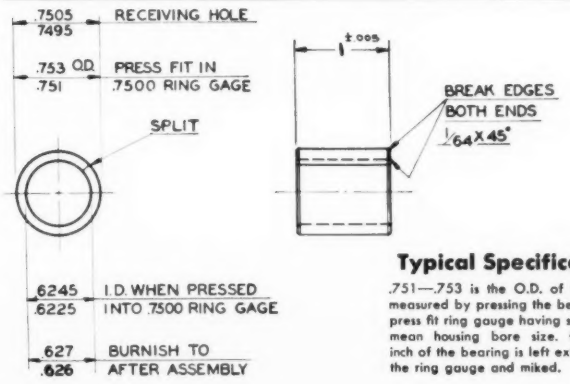
Thrust Washers

Bronze sheet metal is an ideal material for various types of washers, thrust plates and other flat pieces. As such it is available either in the form of the completed product, made to exact specifications or in rolls for fabrication by the user. This material can be secured either plain, serrated for graphite, or ball indented for the retaining of grease.

Johnson engineers are always available for consultation on all types of bearing problems. Their advice is available without obligation.

●

This bearing data sheet is but one of a series. You can get the complete set by writing to



Typical Specifications

.751—.753 is the O.D. of the bearing measured by pressing the bearing into a press fit ring gauge having size equal to mean housing bore size. One-quarter inch of the bearing is left extended from the ring gauge and miked.

Johnson Bronze

SLEEVE BEARING HEADQUARTERS
508 S. MILL ST. • NEW CASTLE, PENNA.

DEPENDABLE!
Makers of timing devices of all kinds tell us that SYNCHRON motors can be depended upon for sustained accuracy and trouble free service under all working conditions

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Operate Efficiently
In Any Position—

Motor is equipped with oil storage reservoir and patented oil feed to bearings. Rotor shaft, reduction train, and output shaft, all have double bearings to reduce vibration and assure quiet, efficient operation when mounted in any position.

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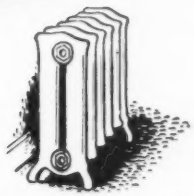

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DURABILITY
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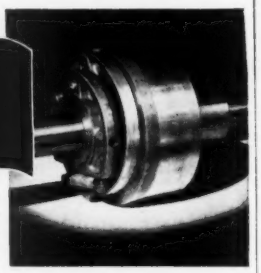
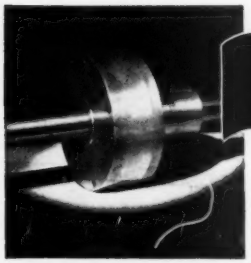
FOR POWER CONTROL DESIGNS

HILLIARD
SINGLE
REVOLUTION
CLUTCH



Unequalled for accurate control of intermittent machine operations — cutting, punching, and packaging. Gives closer tolerances to cut-off, stamping, shearing, and similar machines. Completely automatic; manual, mechanical, or electrical control.



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Hilliard Over-Running Clutches and Couplings are automatic in operation. They are unexcelled for automatic two-speed drives, dual drives, stand-by drives, and for allowing machinery to "coast" after drive stops. Excellent as fixed or infinitely adjustable ratchets.

HILLIARD
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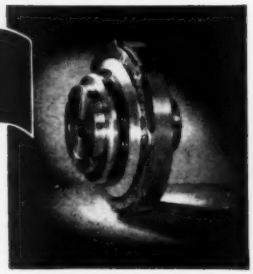
CLUTCH



A reliable series of spring-loaded slip clutches and couplings. Rugged construction with ample friction surface for heavy-duty use. Outstanding for preventing overloads and shocks; for starting heavy loads; as tension drag brakes; for reeling and winding operations; and many other uses.

Hilliard's Engineering Department is ready to assist you in designing installations and in selecting the correct clutch or coupling.
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THIS RESILIENT MOUNT makes for quiet, vibration-free operation. Its die-cast base is a neat, workmanlike job, and the rubber insert is made to fit it like a glove. It is another example of the "engineered efficiency" that gives K-C Motors their ability to render long, hard service.

Cool

Because they run cool, stay cool even under tough conditions of continuous operation, K-C Motors are winning the approval of more and more design engineers. You get plenty of power in a compact, rugged K-C Motor, plus style, to enhance the good looks of your own equipment. Wherever small motors play a big part in performance, specify the versatile, adaptable, long-life K-C. Write us for complete details.

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Kingston-Conley Division
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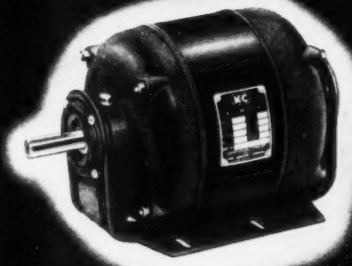

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1/50 TO 1 H.P. — 1750 R.P.M.
Compact, one-piece construction. Convenient for small equipment. 15° rated torsional deflection gives excellent vibration isolation.

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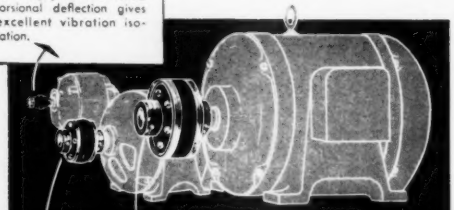
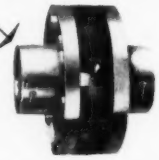


LORD Flexible Couplings

1/50 to 100 h.p.

2 TO 15 H.P. — 1750 R.P.M.
Simple 3-piece construction. May be installed without moving equipment. No need to dismantle entire assembly. Low assembly costs. Highly flexible yet strong. 15° deflection.



20 TO 100 H.P. — 1750 R.P.M.
The answer to destructive torsional vibration from high power drive systems. Removable flexing joints enable replacement without moving equipment. 3° deflection.

The development of Lord M.H.P. Couplings completes the line of Lord Flexible Couplings from 1/50 to 100 h.p. and greatly extends the possibilities for product improvement and customer appeal.

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Bulletin 201 describes the complete line of Lord Flexible Couplings. See our bulletin in Sweet's 1949 File for Product Designers or write for Bulletin 900 showing Lord Vibration Control Mountings and other Bonded Rubber Products.

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LORD Vibration Control Systems

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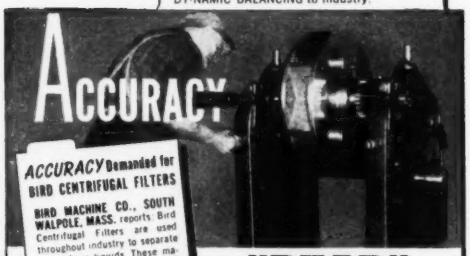

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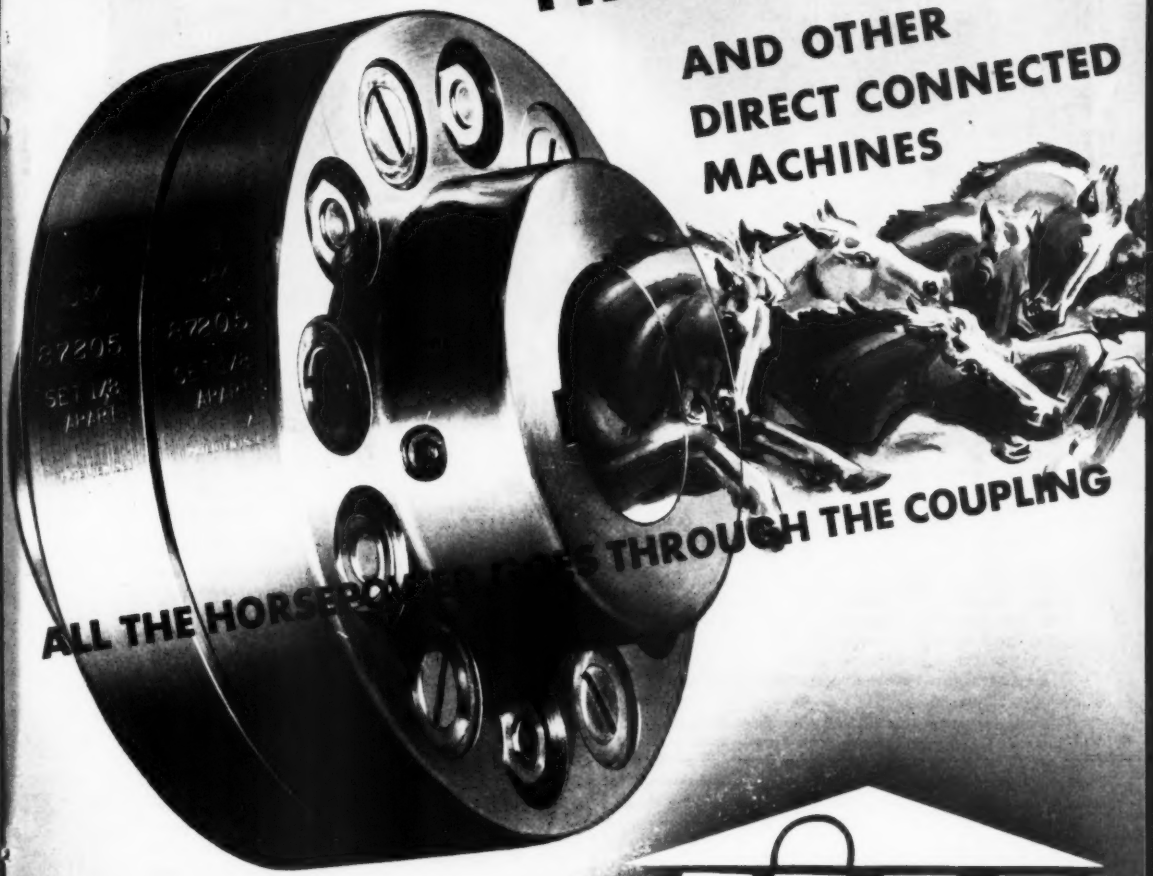

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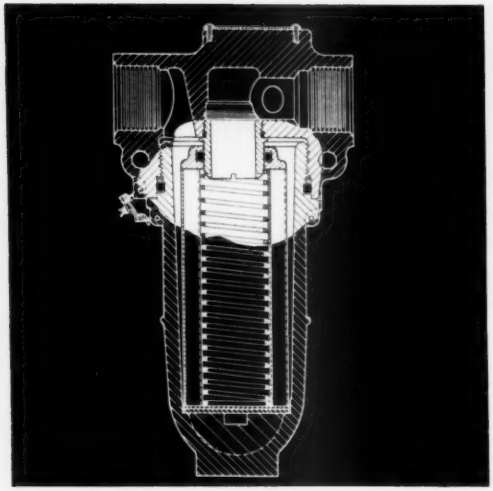

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Yes, LINEAR "O" rings give unlimited sealing performance whether installed in aircraft units flying at high altitudes or operating in a thousand-and-one different installations on the ground. After exhaustive tests, Purolator Products determined that LINEAR "O" rings, used in their automotive and aircraft filters, are resilient and tough enough to fully withstand shock and vibration as well as extreme pressures and temperatures.

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In addition to a long list of natural or synthetic rubber compounds adaptable to a wide range of temperatures, gases and liquids, LINEAR is successfully moulding "O," "V," "U" or other shapes of Kel-F, Teflon and Silicone for special applications. These special materials are suitable for seals from minus 320° F. to plus 400° F. against concentrated sulfuric, hydrofluoric, hydrochloric and other vigorous oxidizing materials.

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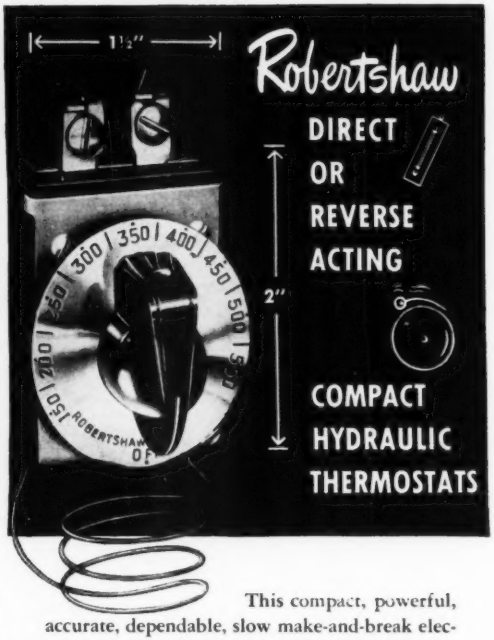

This compact, powerful, accurate, dependable, slow make-and-break electrical thermostat serves a multitude of needs.

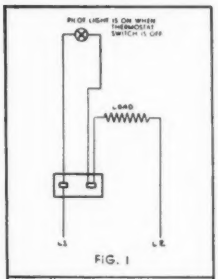

FIG. 1

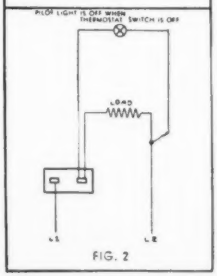

FIG. 2

MODEL B-10
DIRECT ACTING TYPE

Breaks the circuit on the rise of temperature, is particularly suitable for dishwashers, sterilizers, steam tables, water heaters, warming tables, scalding tanks, etc.

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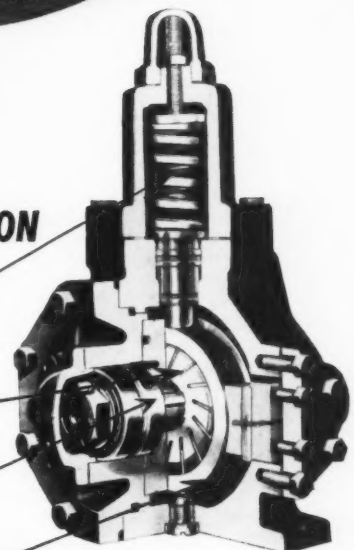

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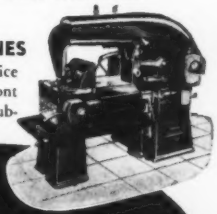

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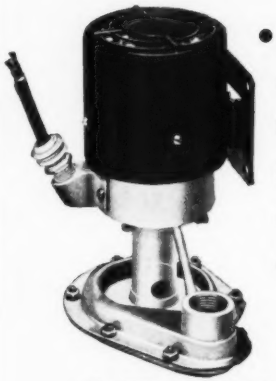

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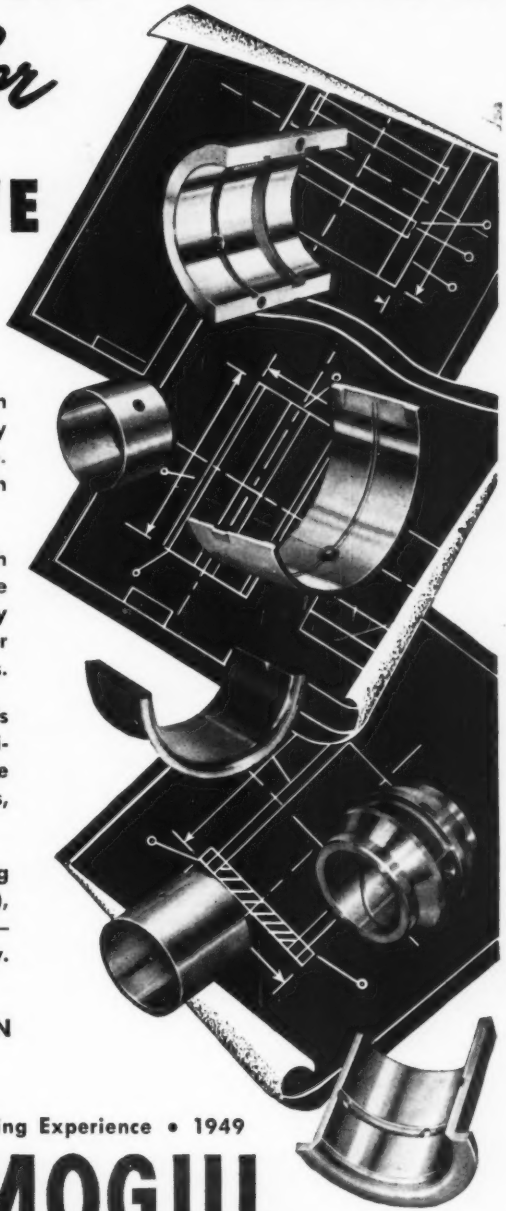

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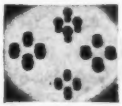

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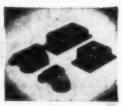

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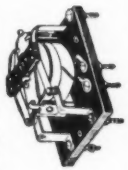

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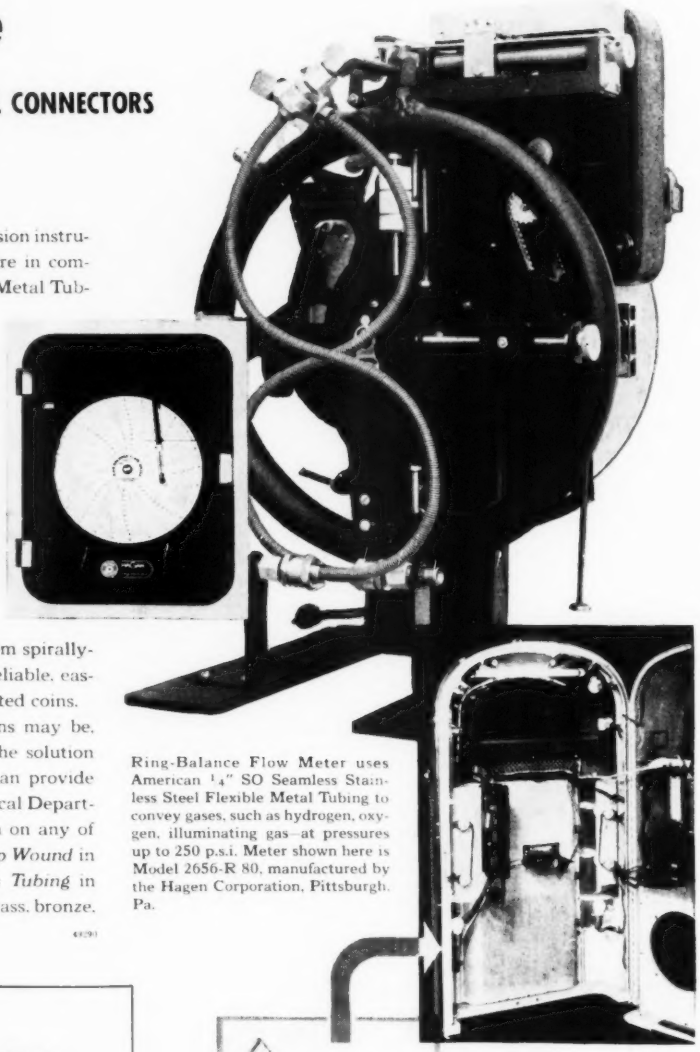
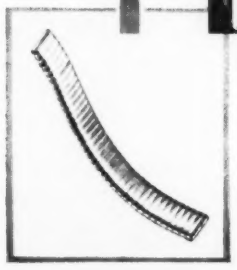
In the Rock-Ola Coin-operated phonograph flexible metal hose, oval in cross-section and made from spirally-wound aluminum strip, forms a reliable, easily-installed return chute for rejected coins.

Interesting as these applications may be, you will be more satisfied with the solution American Flexible Metal Hose can provide for your own problem. Our Technical Department is available for consultation on any of our flexible metal hose types: *Strip Wound* in I.D.'s through 12" and *Seamless Tubing* in I.D.'s through 4"—both types in brass, bronze, stainless steel, nickel, etc.



Ring-Balance Flow Meter uses American 1/4" SO Seamless Stainless Steel Flexible Metal Tubing to convey gases, such as hydrogen, oxygen, illuminating gas—at pressures up to 250 p.s.i. Meter shown here is Model 2656-R 80, manufactured by the Hagen Corporation, Pittsburgh, Pa.



Arrow points to American Oval UI Aluminum Flexible Hose as used for the coin rejector chute on coin-operated phonographs made by the Rock-Ola Manufacturing Co., Chicago, Ill. Construction of this hose is shown at left.

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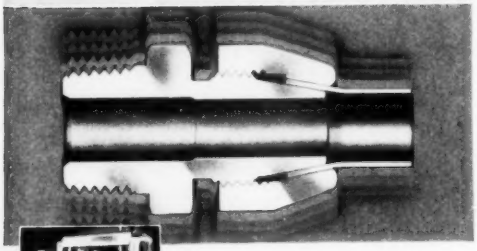
Vibration under high pressure?

Superseal

Flared Tube Fittings make light wall tubing practical



Jaeger Mfg. Co. compressors have Superseal Fittings.

Would you switch to light wall tubing if you could obtain fittings that withstand vibration under high pressure?

Then you'll be interested in Superseal Flared Tube Fittings which are now standard equipment on steam generators and on air compressors with pressures running up to 600 P.S.I. The same fittings in an Underwriters' Laboratories test maintained a leakproof joint under pressures up to an amazing 8090 pounds, at which pressure the steel tubing split. Grinnell Company, Inc., Providence 1, R. I.

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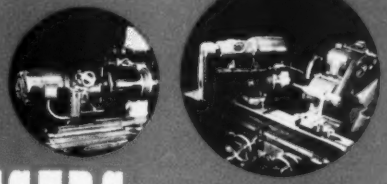

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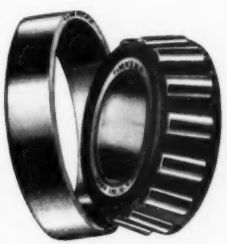

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